

The **AMSAT**[®] Journal

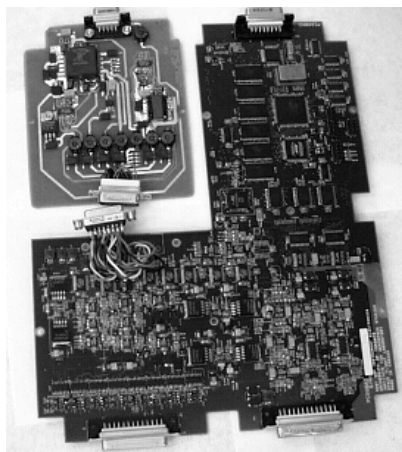
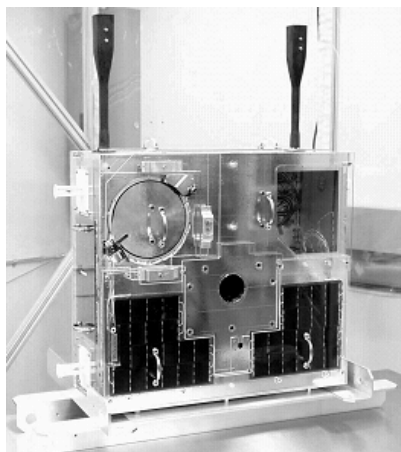
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Volume 27, Number 1

January/February 2004

Exploring for Exoplanets with a Microsatellite!



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EDITOR'S NOTES

by Ed Long, WA4SWJ • wa4swj@amsat.org

Hello everyone. I'm the new editor of The AMSAT Journal. The first thing I'd like to do is apologize for the delay in getting the last issue out. I took it on in the middle of the process and it took a while to get everything going. Hopefully that won't happen again. This issue came together pretty well and the process should only get better in the future.

I would like to thank John Bubbers and Bill Hook for helping out tremendously. They do an excellent job of reviewing and checking for mistakes throughout the editing process. Also, John has the fantastic ability to translate German articles from our sister publication, AMSAT Journal - DL. Several of the articles in this issue were translated by John. Great work! Also thanks go to Russ Tillman (former editor) and Robin Haighton for helping as much as they could as well.

The first thing you should notice is that the format of the Journal has been changed

considerably. A number of people I talked to thought that a "freshening" of the look was important. I took on that task and you're looking at the result. I corrected the logo (the arrow around the earth was too fat) and I added some graphic details for interest. The grid on the front cover reminds me of the reflectors some of us use for the dish antennas we have for communicating through some of the satellites. The grid/reflector also reflects the work that our authors have done to develop their ideas and contributions to our hobby. I applied the grid to the masthead as well for some consistency.

You'll also see some small graphics I've added for interest. I'm not much of an artist so if you have suggestions or can draw better graphics I would be happy to have them.

Now for articles. Simply put - I need them!! If you are thinking of writing an article for the Journal please let me know. We can help you get it completed, edited and placed into

the Journal. I have developed a new Author's Guide, which is on the AMSAT Web site and is available for you to download. That document explains what we are looking for and how to go about writing it. It's not nearly as hard as you think and you could be published. Again, please contact me if you need help or advice on writing. I will respond to you!

Finally, I don't expect to occupy space in the Journal every month. I just wanted to introduce myself and let you know what is going on editorially. Thanks for your support of AMSAT. I hope you like the new look and enjoy this issue of *The AMSAT Journal*.

73,

Ed Long, WA4SWJ

Editor, *The AMSAT Journal* 





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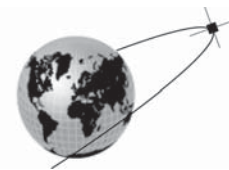
The AMSAT Journal (ISSN: 1407-3076) is published bi-monthly (Jan, Mar, May, Jul, Sep, Nov) by AMSAT-NA, 850 Sligo Avenue, Suite 600, Silver Spring, MD 20910-4703. Telephone: 301-589-6062, fax: 301-608-3410. Periodicals postage paid at Silver Spring, MD and additional mailing offices. **Postmaster:** Send address changes to *The AMSAT Journal*, 850 Sligo Avenue, Suite 600, Silver Spring, MD 20910-4703.

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The AMSAT Journal staff is always interested in article submissions. Whenever possible, submissions should be sent via e-mail to journal@amsat.org using plain text or word processor files; photos or figures in TIF, GIF or JPEG formats. AMSAT-NA reserves the right to select material for *The AMSAT Journal* based on suitability of content and space considerations. The editors of this publication are volunteers giving freely of their talents, time and efforts to produce *The AMSAT Journal*.

APOGEE VIEW

by Robin Haighton, VE3FRH • ve3frh@amsat.org



Another New Year and one of great promise for AMSAT as our new satellite, Echo, should be launched in the second quarter with a launch window commencing on March 31 and extending out for a period of two months. However, let me provide just one word of caution. As you are aware AMSAT's launch record has been very successful over the years, and I do expect to maintain that record, but satellite launching is "Rocket Science" and the operation of satellites, has certain risks as insurance companies will tell you.

The "G" forces during launch are high, so we must make doubly sure that all equipment can withstand these forces in every plane. After launch Echo will be in a very different environment to that on Earth, now it will be subject to both high and very low temperatures, often at the same time when one side is in the Sun and another side is in shadow. The satellite will be subject to radiation from the Sun plus the occasional high-energy radiation burst from a sunspot or similar eruption.

So you might ask "why are we spending all this money and effort for a possible problem?" Well, the answer is very simple – based on AMSAT's record to date, combined with the record of the launch agency, I believe that our odds of having a successful launch of Echo are better than 10 to 1 in favor. Where else could you get odds better than that? But, I would be wrong if I were not to point out to you that there is always a small possibility of problems.

In my opinion the chances of a major problem are quite small, but there are several minor problems, which would hardly effect our operation that could happen. For example a small change in the planned orbit due to any number of things during launch could occur. Orbital changes, unless major, would hardly effect our operations and would be taken care of in modified "Keps". I will not elaborate any more, I just want everyone to realize that we are dealing with a situation that, while is very positive, is not 100% guaranteed.

The new year of 2004 brings AMSAT a new outlook as far as your Board of Directors (BoD) and officers are concerned. At the elections of last year you chose some new BoD members who are very enthusiastic supporters of the organization, and it is a pleasure to work with this "New Board". Each member now embraces certain aspects of AMSAT, and not only makes decisions based on your requirement, but also is active in carrying out those decisions.

For example we have now produced our first Annual Report for 2003. You may download a copy from the AMSAT Web Page. The Annual Report will be used to solicit funds from other organizations. AMSAT is preparing a detailed membership survey, to be sent to members at random. We hope this will provide an accurate picture of member requirements. If you are one of the chosen (at random) members who receive this document, please do fill it in and return it in the supplied envelope.

The BoD is meeting in February 2004 to review and re-new our strategic plan. The world has changed dramatically since our current plan was produced in 1999. Another change has been the addition of an AMSAT Marketing Manager, something we probably should have had for 10 years. Now you will begin to see AMSAT publicized in many other places other than just our own Web site. Talking of which, watch our Web site carefully, it is due to have major changes in the relatively near future.

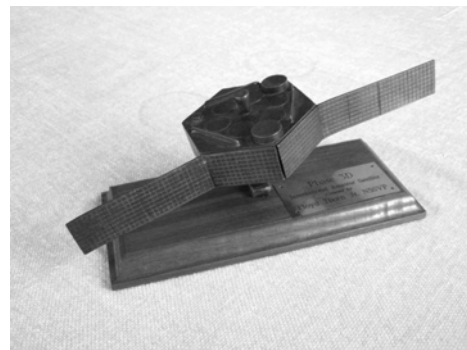
When Echo is launched we will be returning our view to Eagle, our next high orbit bird. Much of the structural design concept work on Eagle has already been completed, but detailed drafting, etc. remains yet to be completed. Of course, Eagle will require another funding campaign – more on that later.

Yes, 2004 will be a very busy year, but the potential rewards to the AMSAT membership are great. The year will also see my "retirement" as President of AMSAT-NA, but you can be assured of my continuing interest and support.

73,

Robin Haighton, VE3FRH

President, AMSAT-NA 



Thank you to the family of Floyd Thorn, Jr., N5SVP (SK). This sculpture, created by N5SVP, was auctioned to raise funds for the Echo launch.



What is AMSAT®?

AMSAT members are a worldwide group of enthusiastic individuals designing, building and operating Amateur Radio satellites as part of our program of space science education.

The Radio Amateur Satellite Corporation (AMSAT or AMSAT-NA) is a non-profit scientific and educational organization chartered in Washington, DC, in 1969. Since then, AMSAT and colleague organizations around the world have built over 50 ham radio satellites. Fifteen of these satellites continue in operation.

Joining AMSAT supports our current projects: Eagle, AMSAT-OSCAR-E (Echo) and ARISS. Eagle is a high orbit DX capable satellite planned for a 2007 launch. Echo is a low orbit FM and digital bird you will be able to use with simple equipment, planned for launch in 2004. And ARISS is our program on the International Space Station. You will keep up to date on the world of Amateur Radio satellites with 6 issues of the AMSAT Journal every year.



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Included at the amsat.org Web site are forms for single sided printing ... just print, cut, fold and mail. You can also find forms for double sided printing if you prefer.

You can find the AMSAT QSL inserts on-line at:

<http://www.amsat.org/amsat/amsat-na/membership.html>

(right) Rick Hambly, W2GPS, AMSAT Executive VP, shown viewing the AMSAT QSL insert.



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Exploring the Mysteries of the Cosmos on the MOST Microsatellite Mission

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Introduction

The MOST (Microvariability and Oscillations of STars) astronomy mission under the Canadian Space Agency's Small Payloads Program is Canada's first space science microsatellite and was successfully launched in June 2003. The MOST science team will use the satellite to conduct long-duration stellar photometry observations in space. The primary science objectives include: measuring light intensity oscillations in solar type stars; determining the age of nearby "metal-poor, sub-dwarf" stars, which will in turn allow a lower limit to be set on the age of the Universe; and detecting the first reflected light from orbiting exoplanets and using it to determine the composition of their atmospheres. To make these measurements, MOST incorporates into a microsatellite design a

small (15 cm aperture), high-photometric-precision optical telescope and a high performance attitude control system that is revolutionary in its pointing accuracy for a microsatellite (see Figure 1).

One of the key challenges for the MOST microsatellite team has been access to space. MOST was initially to launch as a secondary payload accompanying the Radarsat-2 satellite. Delays in the Radarsat-2 program have pushed its launch into 2005. To gain quicker access to space, the Canadian Space Agency contracted with Eurokot Launch Services to provide a launch on 30 June 2003 from the Plesetsk Cosmodrome in Russia.

The paper begins with a description of the science goals of the MOST satellite. These will be shown to have led to a particular choice of orbit and launch vehicle to make space accessible for this microsatellite. This is followed by a description of the satellite design, and the impact that changing launch vehicles to obtain faster access to space had on the MOST program. Finally, the present status of the MOST program is discussed.

Scientific Goals

Size doesn't always matter. Stellar seismologists exploit extremely tiny surface vibrations of stars, detected through brightness oscillations with amplitudes of a few parts per million, to probe stars' hidden interiors and ages and address big questions such as "What is the age of the Universe?". A big telescope is not needed to study many of the Sun's nearer neighbors in the Galaxy, which are bright enough to provide large photon fluxes and high signal-to-noise. However, atmospheric turbulence plus the day/night cycles inherent to single-site ground-based observing mean that a telescope must be in space. Even there, a big budget is not necessary, if we take advantage of proven optical and detector technology

and recent advances in microsatellite attitude control.

Until recently, performing optical astronomy experiments from a low-cost microsatellite (mass < 100 kg) was considered unfeasible because of the poor pointing possible from a platform with such small inertia (approx. $\pm 2^\circ$). In 1997, anticipating new microsat attitude control technology being developed by Dynacon Inc., a team of astronomers and aerospace engineers first proposed to the Canadian Space Agency (CSA) a project to obtain astronomical photometry of unprecedented precision from a microsatellite. In the next year, MOST (Microvariability and Oscillations of STars / Microvariabilité et Oscillations STellaire) was selected to be Canada's first science microsat, as part of the CSA Small Payloads Program. Additional funding was provided by the Ontario Research and Development Challenge Fund, the Natural Sciences and Engineering Research Council (NSERC), the Ontario Centre for Research in Earth and Space Technology and the Universities of Toronto, British Columbia and Vienna.

MOST features a small optical telescope (aperture = 15 cm) equipped with a CCD

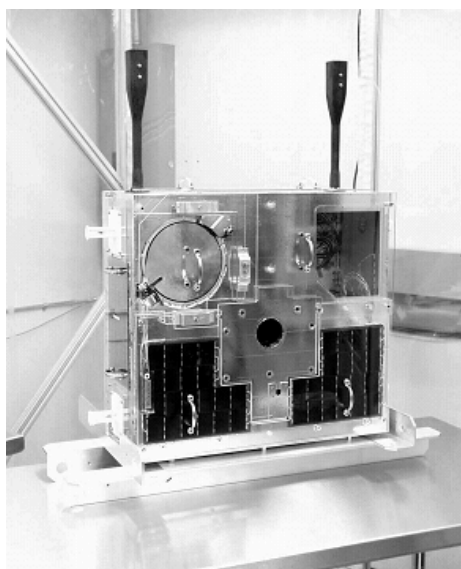


Figure 1
*The MOST microsatellite
(with protective covers)*

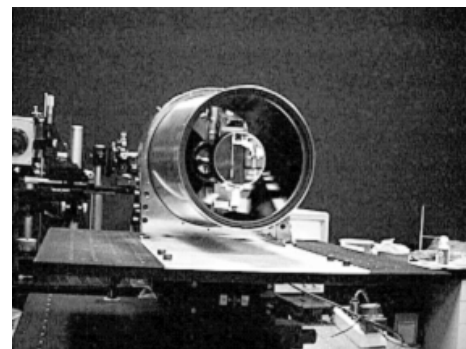


Figure 2
*The MOST telescope
(15 cm aperture)*

photometer designed to return unprecedented photometric precision ($\Delta L / L \sim 10^{-6}$) and frequency resolution ($\Delta \nu \sim 0.1$ Hz) on stars other than the Sun. Given the fact that this instrument (see Figure 2) will be carried aboard a microsat bus about the size and mass of a suitcase, the Canadian public has come to know the MOST mission as the “Humble Space Telescope.”

Probing Mysterious Planets:

Following in Galileo’s Footsteps

MOST was originally designed to detect rapid brightness oscillations in Sun-like stars, to seismically probe their interiors. However, once the project had passed the critical design phase, it was realised the MOST instrument was more sensitive and versatile than originally expected in Phase A. It also had the potential to detect reflected light from some of the giant planets recently discovered to be orbiting other nearby stars. The amount of light reflected and scattered back to Earth by such an exoplanet (Figure 3) would vary during the planet’s orbit, as it goes through illumination phases like those of the Moon or of Venus, as first observed telescopically by Galileo in the early 1600’s.



Figure 3
An artist’s rendering of an exoplanet

Therefore, in Phase C of the project, the MOST team added an exciting new science application, without changing the hardware or software design, or the selected orbit, and at no added cost.

The amplitude and shape of the reflected light curve of an exoplanet depends on the planet’s size, its orbital inclination and eccentricity, and most importantly, its atmospheric composition (which determines its albedo). However, the exoplanet signal is very subtle – about a part in 10⁵ relative to the brightness of its parent star – with orbital periods of a few days for the exoplanets with the smallest orbits. Simulations by Green et al. (2003) indicate that MOST should be able to detect this signal for exoplanet systems like 51 Pegasi

(the first solar-type planetary system to be discovered) and tau Bootis (Figure 4).

MOST would be the first instrument in history capable of detecting these signals and giving direct information about the atmospheres of these mysterious worlds. At the same time, data on the oscillations of the parent stars would specify the ages of these stellar/planetary systems – an important test of models of how these planets formed and evolved.

Why go to space?

It is not currently possible to perform photometry at the precision of 1-10 ppm required for solar-type seismology or exoplanet light curves. For example, if the Sun were observed as a point source (like a distant star), then the net amplitude of its integrated oscillations would be only a few cm/s in velocity and a few micromagnitudes in brightness. Such levels lie about two orders of magnitude below present detection limits for ground-based measurements (although efforts to improve the spectroscopic limits are underway). In fact, even the solar oscillations have been detected in brightness only from space, by the ACRIM bolometer aboard the Solar Maximum Mission, the IPHIR experiment aboard the Phobos probe, and the VIRGO irradiance instrument on the SOHO satellite.

To be able to perform seismology of Sun-like stars and the detection of reflected light from exoplanets requires both:

- Very precise detections of photometric signals as low as a few ppm; and
- Long, nearly uninterrupted monitoring of each star for weeks at a time.

Neither is easy to achieve but getting both simultaneously is virtually impossible from the surface of the Earth.

Scintillation noise

Turbulent cells of air at altitudes of about 10 km in the Earth’s atmosphere have slightly different temperatures that change their refractive indices. As these cells, of order 10 cm across, are carried over the beam of a telescope, they modulate the intensity of starlight randomly and rapidly. This is the cause of star “twinkling”; i.e., atmospheric scintillation. Scintillation is the dominant source of photometric noise in measurements of oscillation amplitudes below about 0.1% (1000 ppm) and at timescales of only a few minutes. This noise term depends on the position of the star relative to the horizon, the exposure time, and the altitude and aperture of the telescope. Scintillation noise decreases with increasing aperture. As the light collecting area becomes larger, the incoming stellar signal is integrated over a

larger number of turbulent cells and their effects begin to average out more effectively.

Consider a set of 60-second photometric measurements from the summit of Mauna Kea, Hawaii (altitude = 4200 m) of a bright star (apparent visual magnitude $V = 3$, about the brightness of the North Star) at the zenith. To reduce the scintillation noise to the order of 10^{-5} in a single reading, you’d need a telescope almost 100 meters across!

Continuous monitoring

From the Earth, an astronomer has only limited options if she wants to monitor a star continuously for times much longer than half a day:

- Observe from a site near one of the poles during prolonged night.
- Operate a network of telescopes spread in longitude around the globe so that at least one of the sites can observe the star in darkness at all times.

(Both these options require the astronomer to be somewhat religious, since she has to pray for clear weather everywhere for weeks at a time.)

The first approach is frustrated by the less-than-ideal conditions for stellar photometry in the Arctic and Antarctic, although there are plans for a South Pole stellar observatory, which may experience photometric conditions in the near infrared. The latter approach has been used successfully by the Global Oscillation Network Group (GONG) to study the low-amplitude velocity oscillations of a very bright source (the Sun), and by the Whole Earth Telescope (WET) to study the relatively high-amplitude (10%) oscillations of faint sources (pulsating white dwarfs). Both approaches are expensive of money, facilities and human resources.

However, neither of these approaches can avoid the scintillation limit. Even if five of the world’s existing 4-meter-class telescopes in Hawaii, the continental U.S., Chile, Spain, and Australia were dedicated to searching for solar-type oscillations in a bright star ($V = 3$) for over 6 weeks, they would still fail to detect the 4-ppm signal represented by the Sun’s oscillations, or even a signal 10 times larger associated with the reflected light of a close-in giant exoplanet.

The “Humble Space Telescope”

The MOST instrument is a Maksutov telescope fed by a flat “periscope” mirror, which allows it to sit in the allowed volume of the instrument bay. The Maksutov optics gives MOST a wide field (about 2° in diameter) so that it can serve as a guiding star sensor for the microsat attitude control as well as a science instrument. The telescope



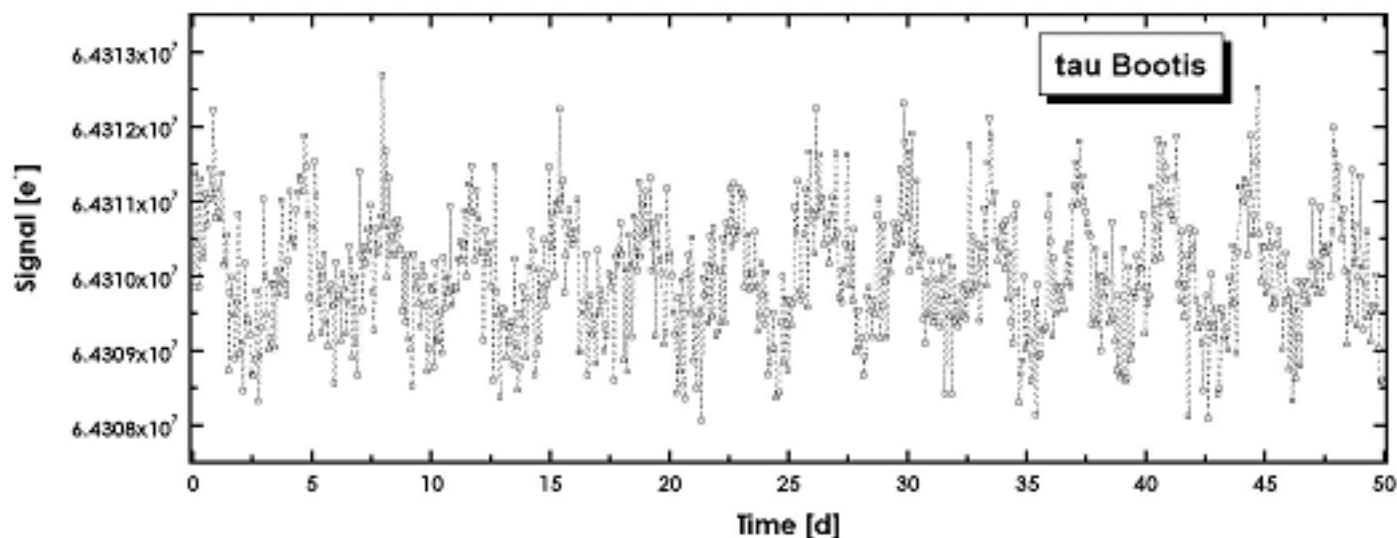


Figure 4
Simulated MOST "observations" of a star with an exoplanet orbiting every 3.3 days

feeds starlight to a pair of frame-transfer CCDs: one for guiding, one for science. Through frame transfer, the integrations can be stopped without the need for a mechanical shutter. In fact, the MOST instrument is designed to have **no** moving parts (to reduce cost and increase reliability). The structure is athermal, so that the optics maintain focus across the wide temperature range between alignment on the ground and the orbital environment.

Light from a given target star is directed onto a Fabry lens, which will project an image of the telescope's pupil onto the CCD: a doughnut with an outer diameter of about 40 pixels. The reasons for the Fabry imaging are three-fold: (1) Spreading the starlight over many pixels reduces the sensitivity of the photometry to pixel-to-pixel sensitivity variations across the CCD, and to damaged pixels and columns. (2) For bright stars, the extended image avoids saturation of the individual pixels. (3) As the microsat wobbles in space by up to ± 10 arcsec rms, the pupil image will remain fixed on the same pixels, moving by no more than 0.1 pixel. This will make it possible to obtain ultra precise photometry down to amplitudes of a few ppm for stars as faint as $V \sim 6$ (the limit of visibility for the naked eye).

The Right Orbit for the Science

To achieve the photometric sensitivity and Fourier frequency resolution required to meet the MOST science objectives, the ideal MOST orbit would maximize the size of the Continuous Viewing Zone (CVZ) and minimize the stray Earthlight that could enter the telescope aperture. However, the choice of orbit must also be tempered by practical considerations of the radiation environment, up/downlink capability, and of course, cost.

The ideal orbit for such a stellar seismology/exoplanet mission would be far from Earth, with a very large CVZ and little stray Earthlight interfering with the photometry. However, for a low-budget microsat mission, geostationary or L2 orbits are not affordable. So the MOST team was forced to consider Low Earth Orbit (LEO). The most common equatorial LEOs for space astronomy missions, like the Hubble Space Telescope, have inclinations that result in fairly small CVZs at the celestial poles, severely restricting target selection. Therefore, a polar orbit was selected which would provide a large equatorial CVZ.

To fully profit from staring continuously at a target for weeks, the science requirement was $>80\%$ duty cycle for observations, with a goal of $>90\%$. This means that solar eclipses by the Earth's limb and passage through the South Atlantic Anomaly (SAA) must inhibit $<10\%$ of observations within the CVZ. Solar eclipses lead to loss of solar sensing and power as well as thermal shock to MOST. In operation, the normal to the rear solar panels must lie within 30° of the direction to the Sun if the satellite is not to lose too much power for science operations. Radiation damage to the electronics and detectors is also a consideration, as well as periods when high fluxes of cosmic ray strikes could confuse star tracker readings. The SAA expands with altitude, increasing the potential "black-out" time (when observations may be inhibited) for higher orbits. On the other hand, the higher the orbit the less the limb of the Earth cuts into the CVZ to introduce parasitic light and the shorter Earth eclipses will be at one or other of the solstices.

Careful estimates were made of the expected

MOST radiation environment with SPACE RADIATION 4.0 (available from Space Radiation Associates, www.spacerad.com) and they indicated a significant but not serious degradation of CCD performance (dark current increase, hot pixels, reduced charge transfer efficiency, etc.) during the first year in orbit for altitudes from 700 to 900 km. Most degradation is inflicted by passage through the high radiation concentrations of the SAA. A 5 mm thickness of aluminum shielding would largely prevent any degradation except by the most energetic particles. The Invar used in the main tube of the telescope structure and aluminum in the camera housing provides an effective 8 mm of shielding. In fact, much more shielding than this would induce a flux of secondaries more damaging than the primaries themselves.

As a compromise, an altitude of ~ 820 km has been chosen. This gives MOST a CVZ about 54° wide, spanning a range in declination from $+36^\circ$ to -18° . This region of the sky encompasses many bright solar-type stars, including several known to have large exoplanets in orbit around them. The maximum dwell time of a star in the middle of this CVZ is ~ 60 days. Such a long series of photometry with high duty cycle would resolve frequency spacing as small as about $0.1 \mu\text{Hz}$, needed to accurately estimate stellar ages from the oscillation spectrum.

Another important factor in a stellar photometry mission in LEO is scattered Earthlight. The secondary payload accommodation envelope baselined for MOST would not permit a large external baffle. Although the internal baffles have been designed to reduce parasitic light by a factor of 10^{-12} , light from the bright limb of

the Earth would severely affect the photometry. Therefore, one of the most critical specifications for the MOST orbit was that it be Sun-synchronous and dawn-dusk, so the telescope could always look out over the shadowed limb of the Earth. (An orbit with a Local Time of Ascending Node (LTAN) crossing of 18:00 was eventually selected because the associated CVZ contained more targets of primary science interest.) The added bonuses of this orbit are thermal stability (no thermal snaps crossing the terminator except during brief eclipse seasons) and efficient use of the solar arrays on the rear face of the satellite (which would always be directed towards the Sun).

A three-stage Russian Rockot can inject MOST into a near-polar orbit (period ~100 min) inclined at approx. 98.7° to the equator, from the Plesetsk Cosmodrome in northern Russia. The elements of the proposed orbit are given in Table 1.

Altitude of Apogee	844.392 km
Altitude of Perigee	827.528 km
Semi-Major Axis	7206.960 km
Inclination	98.696 degrees
Orbital Period	6088.9 seconds
Local Time of Ascending Node (LTAN)	18h 00 min 0.00 sec

Table 1
MOST orbital elements (planned)

Orbit and launch vehicle selection

The Radarsat-2 orbit, a dawn-dusk sun synchronous orbit, presented an excellent opportunity for the MOST mission. Subsequently the satellite was designed with this orbit in mind. This launch was initially scheduled for November 2001. However, it was plainly obvious early in the design of the MOST spacecraft that Radarsat-2 would not launch on schedule. Early in the Radarsat-2 program, the decision was made to change the spacecraft bus. The planned bus was dropped in favor of a new satellite bus that would be built by Alenia. This introduced a delay of at least 18 months to

the scheduled launch date while the design and build of the MOST spacecraft proceeded. Further delays have resulted due to both payload and satellite bus developments. The Radarsat-2 launch is now scheduled no sooner than early 2005, a delay of more than three years.

This experience highlights one of the major issues regarding access to space for small satellites. Small satellites (i.e. low cost satellites) do not dictate launch schedule. For the most part, inexpensive satellites such as MOST can only afford to launch as secondary payloads. The launch schedule, however, is determined by the primary payload. In our case this could have resulted in a delay of more than 3 years in a program that was anticipated to be only 3 years (excepting operations). This would have been disastrous in terms of both cost and scientific return for the mission.

The strategy for designing the MOST spacecraft has been to use a small team of dedicated professionals. The primary reasons for this are to maintain a flexible team that can rapidly adapt to changing situations, and to keep the overall labor costs low. The larger the workforce, the less flexible it is. However, a small team in which every member is critical can be a double-edged sword. If a delay in the program occurs, every member is still critical and needed for the success of the program. Therefore the cost of the program will tend to increase by a greater percentage for a small team that must be maintained than for a large team that can be trimmed to a minimum number of members during delays.

Considered as a whole, it is still cheaper to use the small team than to use the large team, but the longer a program is stretched out, the less benefit is provided in terms of cost.

In terms of scientific value, a delay of three years would have a significant impact. MOST is the first astronomical photometry mission of its kind. It is the first, but not the only mission. The French COROT mission and the ESA Eddington mission have similar goals only with larger satellites. Therefore there is a certain urgency in getting the MOST satellite into space to perform its ground breaking science.

As a result of the expected and continuing delays in the Radarsat-2 mission, the Canadian Space Agency in 2000 began to search for alternative launch opportunities. Fortunately for small satellites, there are presently a large number of launch opportunities on small Russian launch vehicles. The CSA consulted with the Dnepr, Cosmos and Rockot launch providers amongst others, and entered negotiations with Eurokot Launch Services of Bremen, Germany to launch on the converted Russian SS-19 "Rockot" launch vehicle. The Rockot launch vehicle was selected to launch MOST on 30 June, 2003 – 18 months behind as originally scheduled with Radarsat-2, but still more than 18 months ahead of the presently expected Radarsat-2 launch.

It is at this point that a small, integrated team was particularly useful, because in order to launch on the "Rockot" some key design changes had to be made. The small team was able to adapt well to these changes.

Satellite Design Overview

The MOST satellite design originates from trying to fit as large a telescope as possible, all the electronics to interface with the telescope, the satellite bus equipment that allows the storage and transmission of the science data to the ground, the ACS hardware that is required to maintain better than 25 arc second pointing accuracy for the telescope and a power system to provide enough power to the satellite all into a package that can meet the requirements for launch as a secondary payload on a Delta II launch vehicle (with Radarsat-2 as the primary payload). It probably bears little resemblance to the satellite design that would have resulted had a launch on the Rockot been planned from Day 1. However, that is the nature of microsatellite design.

The telescope is a 15 cm diameter aperture Maksutov telescope that is described in detail in Walker et. al [2]. A periscope mirror allows the long axis of the telescope to lie perpendicular to the aperture of the telescope and therefore fit into the Delta II secondary



payload physical constraints. Attached to the telescope, separate from the satellite bus structure, is a two stage passive cryocooler that is capable of maintaining the focal plane of the telescope at a temperature of -40°C . Covering the aperture of the telescope is a door that is designed to actively close to protect the instrument focal plane from direct sunlight.

The satellite structure is based on a tray stack design. The structure consists of aluminum trays that house the satellite's electronics, battery, radios and attitude actuators. These trays are stacked (see Figure 5) forming the structural backbone of the satellite. To this backbone, the science instrument, a 15 cm aperture Maksutov telescope is mounted with its barrel parallel to the axis of the stack. Six aluminum honeycomb panels, acting as substrates for solar cells and carriers for attitude sensors, enclose the tray stack/telescope assembly, forming the box seen in Figure 1. An actuated telescope door mounted on the star facing side of the satellite protects the telescope focal plane from direct stares at the Sun should the satellite tumble or lose attitude lock.

Satellite Electronic Architecture

The satellite electronic architecture is shown in Figure 6. The housekeeping computer, which is central to the design and the figure, is an off-the-shelf product that has been modified to meet MOST requirements. Based on a V53 processor, the computer's

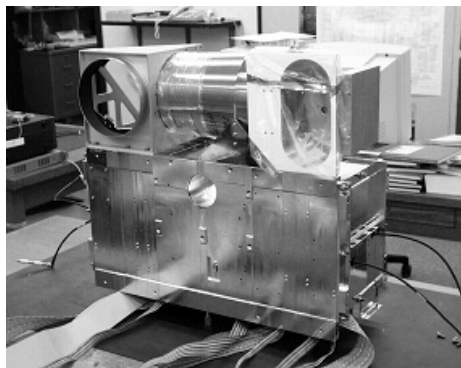


Figure 5
The MOST tray stack and telescope

crystal frequency has been increased from 9 MHz to 29 MHz to accommodate the processing demands of the mission. It interfaces with the rest of the satellite through a custom interface card that provides power, serial and digital I/O connections. The housekeeping computer's main tasks include receiving, executing, and distributing commands and/or files uploaded from the ground, and collecting and transmitting engineering and science data to the ground.

In the figure, roughly from the V53 to the right, the satellite design is typical of AMSAT based designs. It consists of the main housekeeping computer (V53), radio transmitters and receivers including support electronics, and the power system for the satellite.

MOST employs two 0.5W RF output BPSK transmitters and two 2W FM receivers. All radios operate at S-band frequencies. Sufficient downlink margin is maintained by using a 0.5 rate convolutional code, implemented on a custom board. On the uplink, FM receivers provide a simple, robust and low-cost means to talk to the satellite. Both receivers and transmitters connect to custom telemetry and command nodes that serve as modems and telemetry collection devices. To maintain omnidirectional coverage, one receiver/transmitter pair is located on either side of the satellite, connected to quadrifilar antennas. Each radio operates on its own frequency. Thus, the appropriate transmitter is selected based on which receiver is being used.

The power subsystem is based on a centralized switching, decentralized regulation topology. Power regulation occurs through switching power supplies to maximize conversion efficiency (power is very limited in a satellite of this size – 35W in fine pointing operations and only 9W in safe-hold or tumbling operations). While this poses EMC/EMI challenges for the Science DSP computer that must read its CCD Array with almost zero noise, these challenges have been met.

The power system switches are controlled via the housekeeping computer. Two levels of load shed protect the satellite from unrecoverable battery drainage, allowing contingency operations to resume in safe-hold mode. All power lines have overcurrent protection.

In terms of energy storage, a NiCd battery provides power during eclipses and supports peak power draws from equipment such as the transmitters. High-efficiency silicon solar cells on all sides of the satellite generate energy to recharge the battery and provide power for fine pointing and safe-hold operations. Peak power tracking hardware and software (run by the housekeeping computer) maximize the available power to the satellite subsystems.

To the left of the V53 computer is the equipment that makes the MOST satellite unique for a microsatellite in the scientific contribution that it can make. These are the electronics to support the telescope, and the ACS hardware and electronics. The ACS

equipment consists of magnetometers, sun sensors, a star tracker for sensing and magnetorquers and reaction wheels for actuation. The key developments here have been the use of reaction wheels for three-axis attitude control, and the development of a star tracker that is a fundamental part of the science telescope. Combined these enable the satellite bus to maintain pointing accuracy of less than 25 arc seconds.

Science and star tracker images are taken on dual 1024x1024 CCD arrays that share the focal plane of the telescope. Each CCD is connected to a pre-amplifier, and to analog and digital electronics boards (Figure 7). These boards are based around a Motorola 56303 DSP, and provide digital control and Analog to Digital conversion of the signals from the CCDs. The instrument computers are designed to provide nearly noiseless CCD readings while tolerating disturbances from switching power supplies.

There are four attitude control modes for the satellite:

Safe-Hold: The satellite is essentially power positive in all practical orientations. Therefore, this is an uncontrolled state in which there is no active attitude control. In this mode, the focus is nominally on commissioning or recovery operations.

Detumbling: This mode involves using the magnetometers and magnetorquers to implement B-dot control to slow the tumble rate of the satellite so that coarse pointing control can be executed. Normally this is used after kick-off from the launch vehicle.

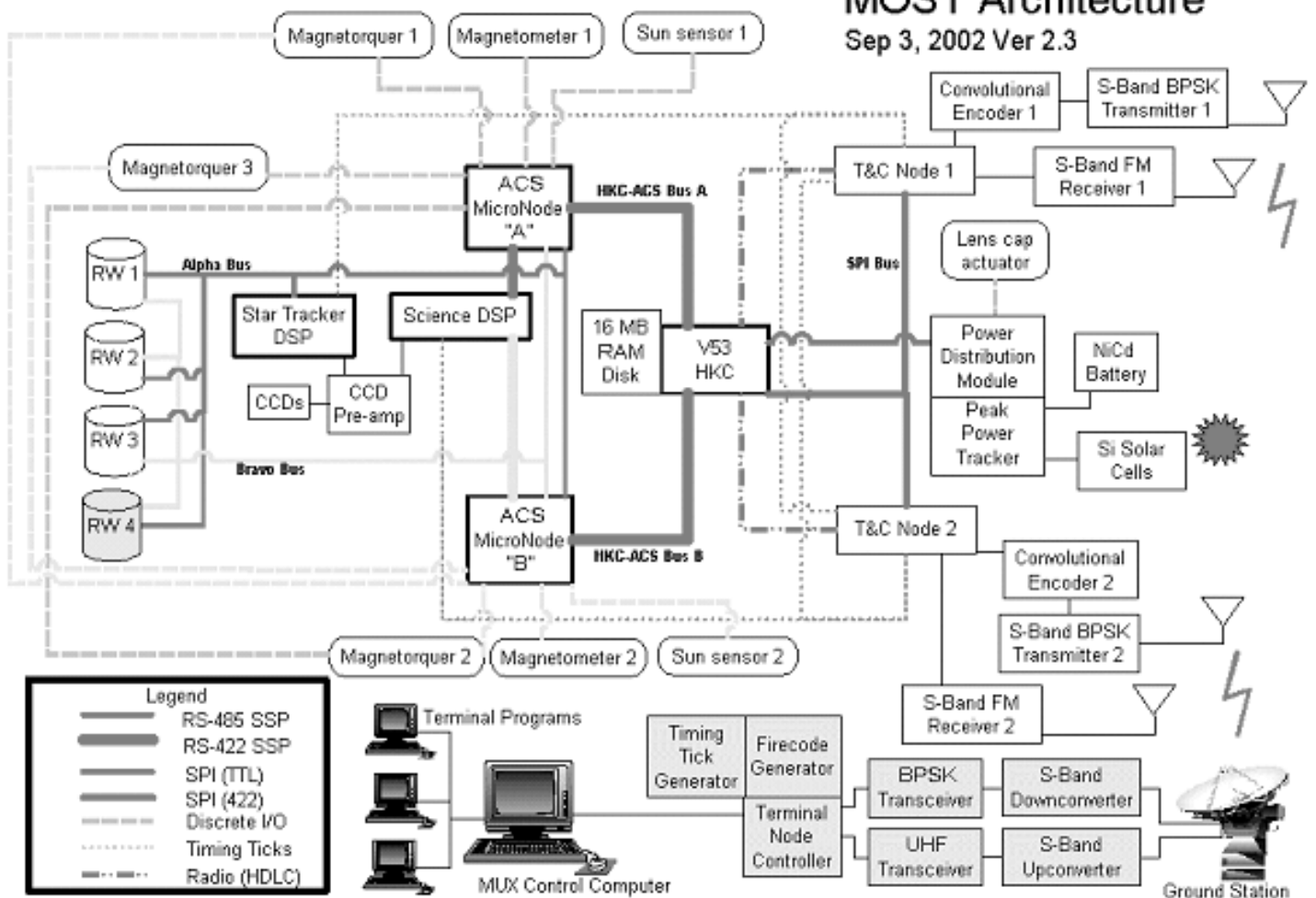
Coarse Pointing: After the satellite is detumbled, the ACS uses sun sensors and magnetometers to determine the spacecraft attitude, while using reaction wheels to control the attitude to orient the main solar array towards the Sun and to roughly point in the direction of science interest. The magnetorquers are used to desaturate the reaction wheels.

Fine Pointing: The ACS the star tracker to determine spacecraft attitude to an accuracy of three arc seconds. The reaction wheels are used to control the attitude. The magnetorquers are used to desaturate the reaction wheels.

The attitude control computers (ACS nodes) are also based on the Motorola 56303 DSP. The DSP acts as the fundamental processing unit that runs the ACS software. The computers provide analog control of the magnetorquers, power and analog to digital conversion of the magnetometer and sun sensor signals, as well as RS-485 connections to the main housekeeping computer, the reaction wheels (which contain

MOST Architecture

Sep 3, 2002 Ver 2.3



their own microcontroller) the star tracker and science DSP boards. Nominally, only one ACS node is operational. The second is designed as a cold spare to add redundancy where it was practical.

All computers have Error Detection and Correction (EDAC) hardware and software

to correct for bit errors induced by radiation. Single event latch-ups are corrected by power cycling the affected device.

To ensure that components within the satellite operate at suitable temperatures, a combination of passive surface treatments are used including aluminum, gold and silver Teflon tapes. In the event that the satellite enters a cold state due to a disadvantageous attitude relative to the Sun, resistive heaters are used to keep the battery and trays sufficiently warm. During fine pointing operations, a passive radiator cools the telescope focal plane so as to minimize thermal noise in the CCD readout.

Ground Stations

Three ground stations in Toronto, Vancouver and Vienna are used to download data from MOST. The primary control station is in Toronto (Figures 8 and 9), while the secondary stations (Vancouver and Vienna) will be controlled and coordinated over the Internet. Although the basic mission can be accomplished with just one ground station, additional science data can be acquired using the secondary stations.

The stations used for MOST communications are based on an Amateur Radio core station operating at VHF and UHF frequencies. They are upgraded with

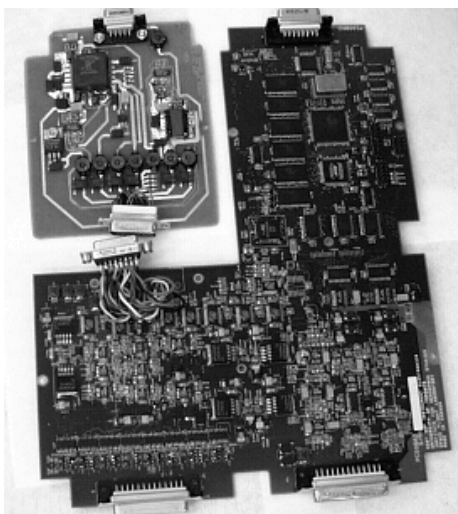


Figure 7
The MOST instrument computer



Figure 8
MOST ground station



S-band transverters and BPSK transceivers connected to a 2-m parabolic antenna (downlink) and a 45-element loop Yagi (uplink). The antennas are mounted on a heavy-duty, precisely controlled rotator located atop a 20-foot tower (Figure 9).

The ground station radios are connected to a custom terminal node controller (combination modem and serial communications controller) which is in turn connected to a computer that coordinates multiple terminals each running interface software for specific components on the satellite (see Figure 6). Through this system, terminal users have a virtual link to their satellite hardware of interest. The terminal node controller also generates "firecodes" or emergency commands to reset satellite hardware. A "timing tick" generator is used to maintain knowledge of clock drift in the instrument computers so as to accurately time tag science observations.

Impact on design as a result of change of launch vehicle

The change from Delta II to Rockot launch vehicle had no significant changes on the electrical design of the satellite. However, there were important changes that were needed in the structural design, and these had an important effect on cost and schedule of the program. The primary difference between accommodation on the Delta II and the Rockot launch vehicles is the payload adapter interface. The Delta II uses a 9-inch Marmon clamp (see Figures 10 and 11), while the Rockot uses a pyrolock mechanism (Figure 12). The pyrolock mechanism has as very different interface to the satellite. It consists of a central rod that pulls the spacecraft towards the launch vehicle. There are 3-4 hardpoints that contact the satellite to oppose the preload that is provided by the central rod. At these hardpoints, there are spring pushers to provide separation forces once the central rod is released by the pyro-mechanism.

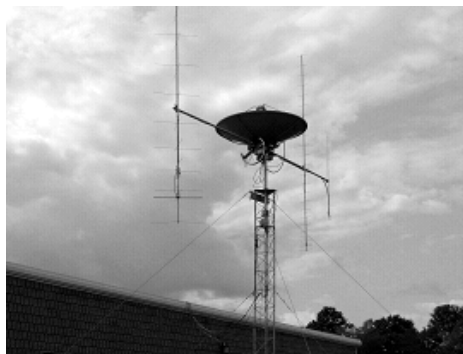


Figure 9
Antenna system at UTIAS/SFL

While negotiations were in progress with Eurockot on the launch contract, work was frozen on the central five trays of the tray structure, and the -X panel of the spacecraft that interface with either the Marmon clamp or the pyrolock mechanism. This resulted in approximately 6 months of delay in the program and the costs that are associated with the delay. (See Figures 13 and 14 for the resulting MOST and payload attach fitting designs.)

Program Status

The MOST spacecraft began environmental test on October 15, 2002 at the CSA's David Florida Laboratory in Ottawa, Canada and completed environmental testing on January 18, 2003. Environmental testing consisted of spacecraft vibration testing, EMI testing and TVAC testing.

The spacecraft was put through a series of low-level sine, high-level sine, sine burst and random vibration tests to qualify the satellite for launch on the Rockot vehicle. For the random vibration tests, a force-limited vibration technique was used to avoid over testing of the satellite (See Scharton [3]).

The spacecraft is nominally unpowered on the launch vehicle. However there is a small circuit that monitors the state of non-contacting separation sensors that is active during launch. The spacecraft was tested to ensure that the launch vehicle RF environment would not result in EMI pickup on the separation sensor lines. This is to ensure that the satellite does not mistakenly engage prior to actual separation from the launch vehicle.

The Thermal Vacuum testing was performed to verify that functionality of all of the satellite equipment over the expected thermal range in a vacuum environment. TVAC tests were performed at the each of the extremes of the thermal range that are expected on orbit. At each of these extremes all of the equipment that is required at these temperatures was functionally tested. In

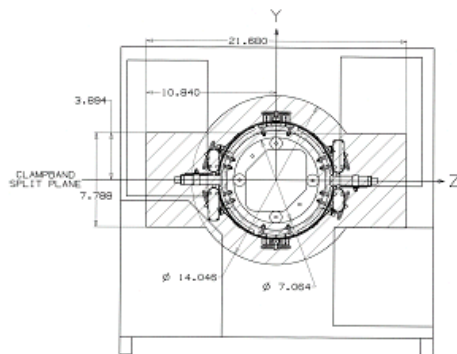
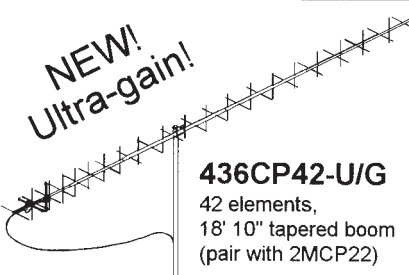


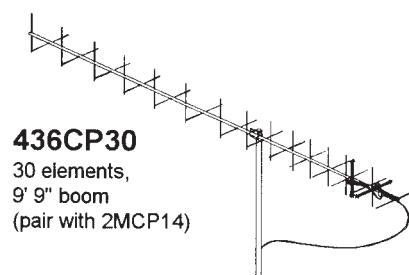
Figure 10
Delta II Marmon clamp attached to MOST

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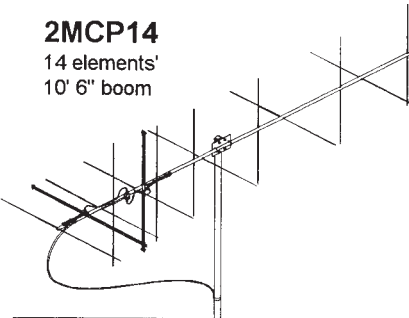
NEW! Ultra-gain!



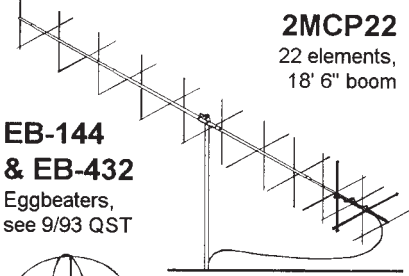
436CP42-U/G
42 elements,
18' 10" tapered boom
(pair with 2MCP22)



436CP30
30 elements,
9' 9" boom
(pair with 2MCP14)

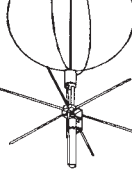


2MCP14
14 elements'
10' 6" boom



2MCP22
22 elements,
18' 6" boom

EB-144 & EB-432
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addition, operational scenarios were tested. These included testing during changing thermal environments that result from the satellite entering and exiting eclipse once per orbit.

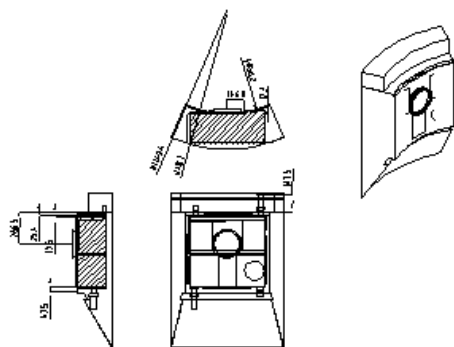


Figure 11
MOST in Delta II secondary envelope

Following environmental testing, the spacecraft completed its functional testing. The functional test plan covers all aspects of unit functionality within the context of spacecraft-level operation. This included testing of the attitude control system, which could not be tested during TVAC. The ACS is functionally tested using a series of tests performed with the spacecraft on a single axis air bearing. On the single-axis air bearing, the detumble, coarse pointing and fine pointing modes of the satellite were checked out and shown to work functionally. Performance testing was not possible in a 1-g environment.

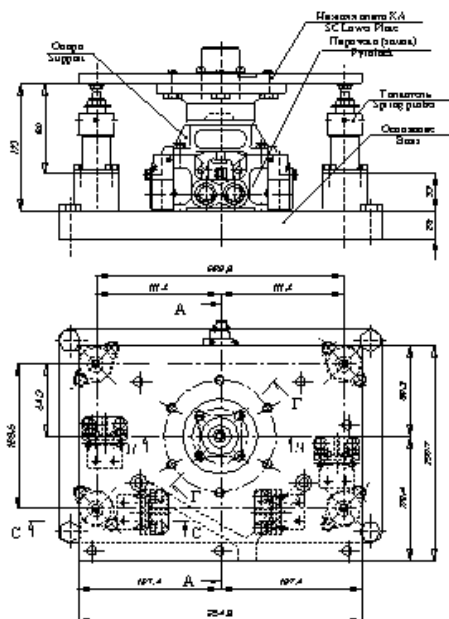


Figure 12
Rockot pyrolock system

The MOST satellite program passed its flight readiness review on 7 May 2003.

On 13 May 2003 the MOST satellite and GSE was shipped from Toronto, Canada to begin its long journey to the Plesetsk Cosmodrome in Russia (Figure 16 shows some MOST team members at the Plesetsk Cosmodrome). The launch campaign began on 26 May 2003 at the Plesetsk Cosmodrome where the satellite was given a final checkout. The satellite was mated with the separation system designed and built by the Khrunichiev State Research and Production Space Center (a 49% partner in the Eurockot consortium). Figure 15 illustrates the activities in the Integration Hall of the Plesetsk Cosmodrome.

Integration with the launch vehicle took place on 14 June 2003. MOST was launched successfully on 30 June 2003.

Within six hours after launch, the satellite was successfully contacted. Telemetry indicated that the satellite was in excellent condition. Commissioning was planned for two months and was to occur in staged manner. First the housekeeping computer would be loaded with software and fully checked out. Then the attitude control computer and its peripherals would be commissioned. Following this, the instrument and star tracker DSPs would be turned on. The satellite was to transition from safe-hold mode to detumbling mode to coarse pointing mode and finally to fine pointing mode. Difficulties with the housekeeping computer combined with stray light interference in the star tracker extended the commissioning period by a couple of months. However, innovative solutions to the problems were developed allowing MOST to meet all of its original objectives.

As of January 2004, the satellite is in normal

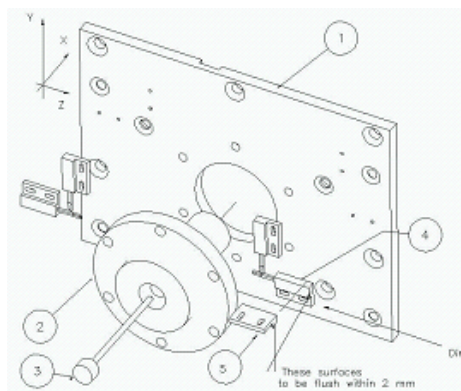


Figure 13
MOST modified to accommodate Rockot pyrolock

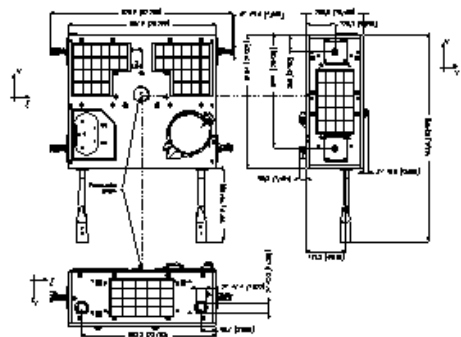


Figure 14
Payload attach fitting to accommodate pyrolock system

science operations mode. Pointing performance currently exceeds expectations (requirement was 25 arc seconds, actual achieved performance is 5 arc seconds). Figure 17 shows a "first light" image taken on 29 July 2003 when the satellite was in coarse pointing mode for the first time. This is a star in the constellation of Capricorn.

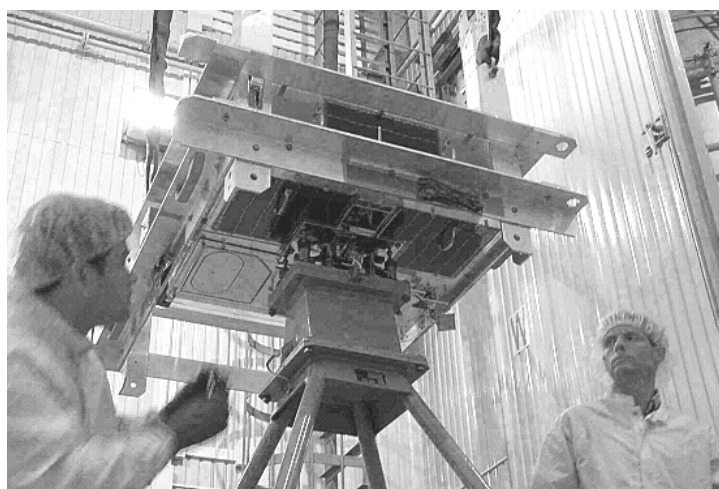


Figure 15
MOST at the Plesetsk Cosmodrome. Shown here is a mating check.





Figure 16

The MOST team at the Plesetsk Cosmodrome. From left to right, Jaymie Matthews, Simon Grocott, Daniel Foisy, Rainer Kuschnig, Hugh Chesser, Alexander Beattie, Anatoly Borshchov (our friendly Russian security official).

The first “doughnut” Fabry image was taken in fine pointing mode on 10 September 2003. The star is 51 Pegasi. Finally, the first MOST detection of known stellar variability in the star Delta Ceti was made in October 2003.

At present MOST is observing Procyon after having looked at some intermediate targets. The astronomy team has already made some noteworthy discoveries that will be published in the upcoming months.

Conclusion

When all is said and done, there are both positive and negative aspects that have been experienced concerning accessibility to space. On the one hand, there has been a negative impact on the cost and schedule the program. The launch of MOST occurred approximately 18 months later than expected, and significant redesign and rework was required that resulted affected the cost of the program.

However, there is a very positive outlook as well. A wide selection of Russian launch vehicles, including the Rockot provided by Eurockot Launch Services, have greatly increased access to space. Without the Russian launch opportunities, the program would have been further delayed, as it would have been tied to the Radarsat-2 launch. Because the satellite, once designed, required a dawn-dusk sun synchronous orbit, the only other alternative would have been to find another primary going to such an orbit and hitchhike with it. However, this orbit is used little enough that there were few other opportunities. Without the accessibility provided by the Russian launch vehicles, the program would have suffered further delays and cost significantly more as a result.

Despite the challenges faced, the satellite was successfully launched on 30 June 2003. It was also successfully commissioned despite obstacles that had to be overcome. The team was able to develop innovative solutions to

bring MOST online. MOST is currently outperforming expectations and the MOST team looks eagerly to the future knowing that scientific discoveries are on the horizon.

Acknowledgments

Dynacon Incorporated would like to thank the program manager for MOST, Mr. Glen Campbell and the Space Science Branch of the Canadian Space Agency for their support and encouragement throughout the MOST project. The University of British Columbia acknowledges the contributions of the Natural Sciences and Engineering Research Council (NSERC) and the Canadian Foundation for Innovation (CFI). The University of Toronto Institute for Aerospace Studies would like to thank the Ontario Research and Development Challenge Fund (ORDCF) and the Center for Research in Earth and Space Technology (CRESTech) for their financial support.

The Space Flight Laboratory gratefully acknowledges the donations and contributions of the following organizations to its microsatellite program:

Agilent Technologies
 Altera
 Altium
 Analytical Graphics
 ATI
 Autodesk
 ARC International
 Cadence
 CMC Electronics
 E. Jordan Brookes
 EDS
 Emcore Photovoltaics
 Encad
 Honeywell
 Integrated Systems
 MDRobotics
 Micrografx
 National Instruments
 Raymond EMC
 Rogers Microwave Materials
 SDRC
 Stanford University, Space Systems
 Development Laboratory

References

1. Mayor, M., & Queloz, D. 1995, *Nature*, 378, 355.
2. Walker, G., Matthews, J., Kuschnig, R., Johnson, R., Rucinski, S., Pazder, J., Walker, A., Burley, G., Skaret, K., Zee, R. E., Grocott, S.C.O., Carroll, K. A., Harron, J., Sinclair, P., Sturgeon, D. "The MOST Astero-seismology Mission: Ultra-precise Photometry From Space" Publications of the Astronomical Society of the Pacific, Volume 115, No. 811, University of Chicago, September 2003.
3. Scharton, T. D. "In-Flight Measurements of Dynamic Force and Comparison with Methods used to Derive Force Limits for Ground Vibration Tests." Proceedings of the European Conference on Spacecraft Structures, Materials, and Mechanical Testing. Braunschweig, Germany, November 4-6, 1998, pp. 583-588. 

AMSAT is the North American distributor of SatPC32, a tracking program designed for ham satellite applications. For Windows 95, 98, NT, ME, 2000, XP.

Version 12.0 now supports 3D maps and auto time zone selection.

Features:

- Graphical tracking on a world map with two selectable Zoom factors.
- One-click satellite switching using 12 "letter" buttons.
- Automatic rotor control support for: Kansas City Tracker/Tuner, FODtrack, Uni-Trac, SatEL, Yaesu GS-232, ARS from EA4TX, EGIS rotors, IF-100, RIF-PC, AMSAT-DL interface, WinRotor32, HalloRotor, WiSP DDE clients.
- Doppler tuning with on-screen frequency displays. Radio models supported: Yaesu FT-736R, FT-847, FT-817 ICOM IC-820H, IC-821H, IC-910H and other ICOM radios Kenwood TS-790 and TS-2000 DDE client programs
- "Transparent" VFO-knob tuning in addition to keyboard and mouse tuning.
- Includes a special version for ISS split-frequency operation.
- Controls subaudible tone on FT-847, FT-736R, and IC-910H.
- Includes a non-graphical version and programs that output lists to the screen, printer, or a file.
- Interfaces with WiSP, with user-defined satellite switching priority.

Price is \$45 for AMSAT members, \$50 for non-members, postpaid on CD-ROM.

A demo version may be downloaded from <http://www.dk1tb.de/indexeng.htm>

A registration password for the demo version is \$40 (members), \$45 (non-members).

Order by calling 1-888-322-6728, or use the online shop at www.amsat.org.

The author, DK1TB, donated SatPC32 to AMSAT. All proceeds support AMSAT.

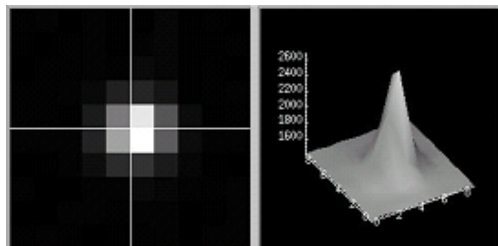
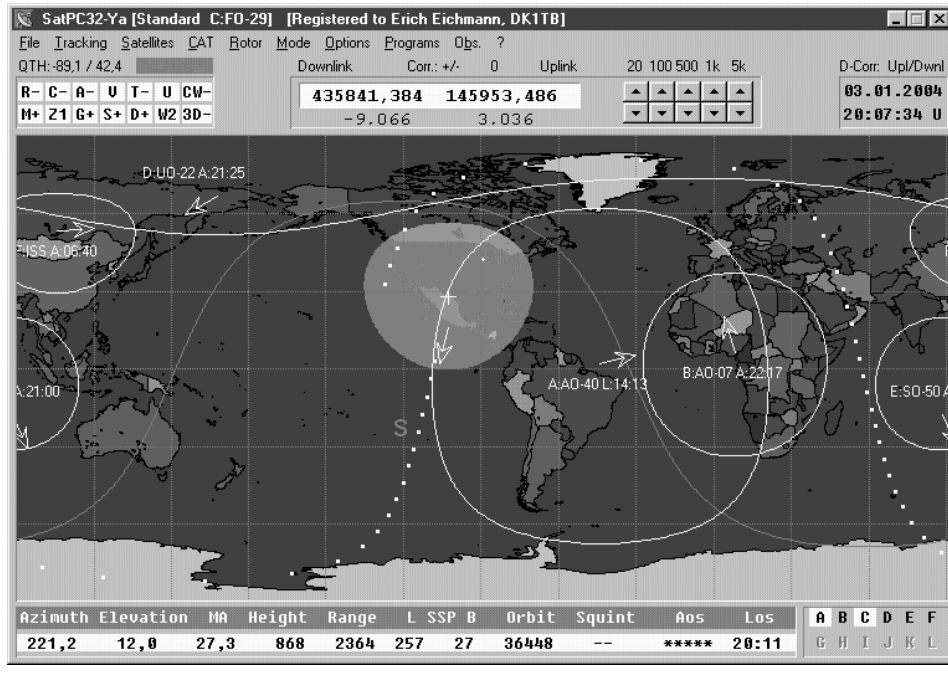
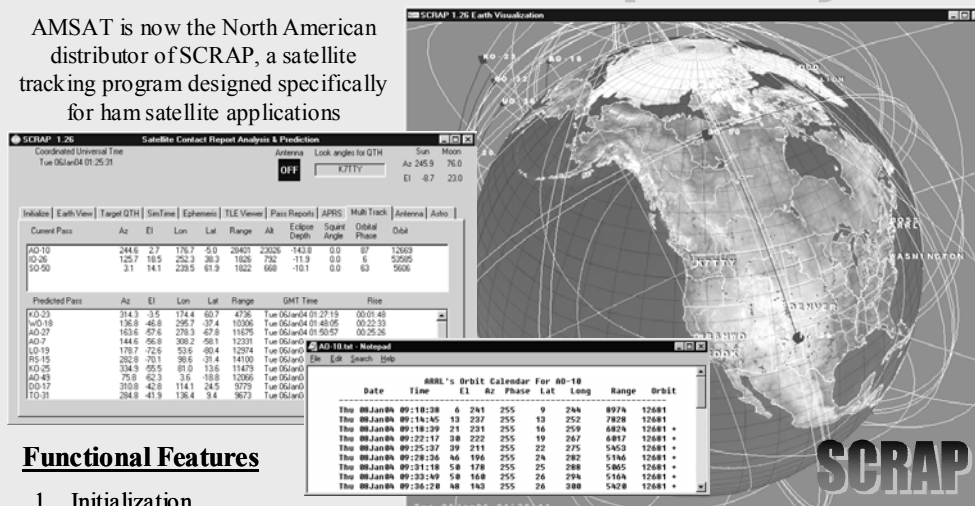


Figure 17
MOST first light image.



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3B9C Rodrigues Island - 2004

by Robin Haighton, VE3FRH

In just a few weeks' time, in mid March, the Five Star DX'ers Association's (FSDXA) expedition to Rodrigues Island in the Indian Ocean will be underway. The UK based FSDXA has assembled an international team of nearly 30 operators and shipped approximately six tons of equipment to the island, which lies 1400 miles off the East coast of Africa. While 3B9 is currently listed by *DX Magazine* as 81st on the "most wanted list", on specialist modes it is considerably rarer than this ranking would suggest. On satellite, 3B9 is one of the few places in the world never to have been activated before. So this will be the first time the country will have been heard via satellite.

The FSDXA has previously organized successful operations from Spratly Island (9M0C) in 1998 and was responsible for the record breaking Comoros DXpedition in 2001 which made 168,772 QSOs on HF / 6m. For Rodrigues, the team has a dedicated station for AO-40 / EME and has included David Bowman, G0MRF, as a 'satellite specialist'.

The principal sponsor, Yaesu, has supported the DXpedition with ten FT1000 Mk5 transceivers and matching Quadra 1kW amplifiers. While these will be used 24 hours a day for four weeks with monoband beams on HF, the satellite station is equipped on a similar scale. 3B9C will use mode U/S on AO-40. The station is based around the popular Yaesu FT-847 transceiver with a GS31B tube based amplifier from Linear Amp-UK. For uplink antennas an array of four horizontally polarized 19-element Tonna Yagis will be stacked and bayed to provide a gain in excess of 20dBd. To receive AO-40 on 2401MHz, an 80cm dish will be used with a 'Gemini' converter. This has a noise figure of 0.55dB and an I.F. output on 29MHz. A set of Azimuth / Elevation rotators complete the satellite station.

3B9C will operate on CW SSB and PSK31 and will welcome QSOs on each of these modes. In the past PSK31 has proved difficult with Doppler shift on S band, causing the receiver to lose lock after a few seconds. A recently available software package called Ham Radio Deluxe could provide an answer to PSK on AO-40. The software can simultaneously decode multiple PSK31 signals within the normal receiver audio bandwidth. Although it requires a 450MHz processor or better, it can automatically track a PSK signal that is moving with Doppler.

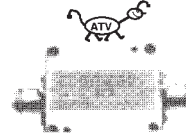


From Rodrigues Island the team will have good mutual windows via AO-40 with Europe, Australia, Asia, Africa and South America. However, running tracking software predictions reveals that communicating with North America on the opposite side of the world will present some interesting challenges. At distances of 12,000 to 16,000km the time available for QSOs will diminish rapidly as you travel westward across the USA. While the East coast will have openings of over three hours per orbit, operators in western states, e.g. Texas, will need to plan carefully, as the window to 3B9 will be short and AO-40 will be just a few degrees above the horizon. The satellite operators on Rodrigues know the rewards of making that 'difficult contact' and they will be following the satellite down to their horizon. Check your tracking software and see if you have a mutual window to 3B9. If you do, no matter how short, 3B9C will be there to give you a new country and possibly your best DX via AO-40.

3B9C will have on-line logs available and these will be compatible with the ARRL Logbook of the world (LoTW.) Further details of the FSDXA DXpedition to Rodrigues can be found in QST (Jan 2004 p.82) or at the group's Web site. www.fsdxa.com/3b9c. A contact e-mail address will be announced in due course, through which you can send comments back to the DXpedition team while the DXpedition is in progress. 🌐



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The AO-40 transponder came back to life in January with lots of DX activity. The apogee of AO-40's orbit is now farther north than it has been since launch. The result is that the northern hemisphere has "wider" windows that allow us to work more distant countries. This is as good as it gets on AO-40 (P3E will have even better DX windows if it reaches its intended orbit). AO-40 operators around the world seem motivated to contact new countries that were impossible to reach a year ago. In addition, this "AO-40 season" has DX windows at convenient times instead of in the middle of the night.

New AO-40 stations are popping up in rare places such as 5T5SN in Mauritania, and UN7PV in Kazakhstan. In addition, AO-40 operators report that V51E plans to be on AO-40 soon from Namibia, and 9K2YM plans to be on AO-40 soon from Kuwait. Ed D2FPN (of North Korea fame) is active from Angola on the HF bands, and plans to set up his AO-40 equipment soon.

Unfortunately, two previously announced DX operations were postponed. Yoshi JF6BCC had to postpone his planned February operation in Guam. Terry K7ASU's assignment to Wake Island has been postponed for 9 months.

LEO satellite activity revived somewhat with AO-27 back in limited service, and SO-50 enabled regularly. Alan N5AFV activated grids on AO-27 and SO-50 during a Caribbean cruise. Hopefully this year's launch of Echo will revive FM satellite DX activity.

Heard on the Air:

SV9ANJ (Crete)
UN7PV (Kazakhstan)
VR2XMT (Hong Kong)
9V1UJ (Singapore)
9M2/JR1WZI (West Malaysia)
DU1/GM4COK (Philippines)
VU2RM (India)

Future DXpeditions:

FT5ZL (Amsterdam Island)

Sabastien arrived on Amsterdam Island on December 24 and plans to stay there for all of 2004. He set up his downlink antenna and reports a high interference level on 2.4 GHz. His uplink antenna did not arrive, so he must either wait for another supply ship to bring the antenna, or build an antenna on-site. The grid locator is MF81tx. Only the eastern and far northwestern parts of the U.S. will have windows.

Multi-island Pacific Expedition

By Rolf DK2ZF, from February 28 thru April 20. He hopes to be on the air from 7 different islands, but this depends on unreliable inter-island travel connections. He has not announced the actual locations. Hardy DC8TS will be the pilot station sharing Rolf's latest plans with the satellite DXing community. Check the HB9DRI AO-40 logger site or Hardy's personal web site for updates.

<http://www.artieda.net/hb9dri/ao40logger/>

<http://go.to/dc8ts>

Rolf plans to spend most of his time on HF, and only operate AO-40 for 1-hour pre-announced DX windows. He will operate 46 kHz below the beacon with split-frequency operation.

XF4IH (Revilla Gigedo) Mar 3-15

This team will include Tony XE1GRR operating AO-40, AO-7, FO-29, AO-27, and SO-50. Grid DK48. QSL via XE1IH.

FO/C (Clipperton Island) Mar. 8-16

This large HF/satellite DXpedition team includes K4SV and VA7DX, who activated Lesotho and Swaziland on AO-40 last year. This time they will have a stronger uplink thanks to an IC-910H provided by ICOM. License and landing permit were pending when this was written.

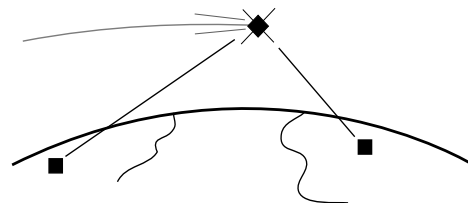
3B9C (Rodrigues Island) Mar.29-Apr.15

G0MRF will operate AO-40 with the 3B9C team. There is no window for those west of the Rocky Mountains.

T33C (Ocean Island) Apr. 4-16

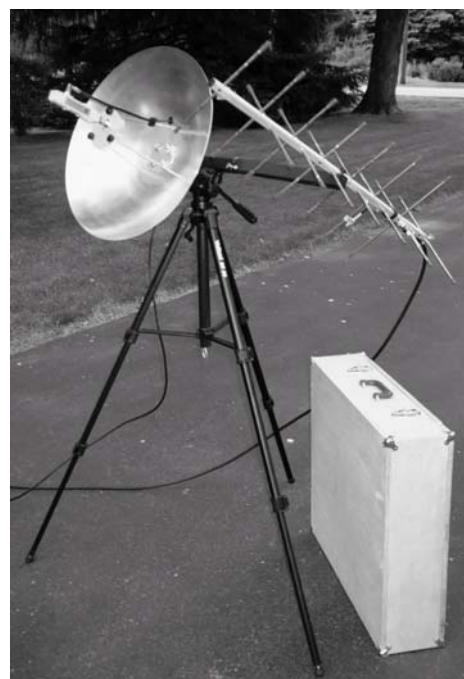
Doug N6TQS will be the satellite operator for this large international DXpedition. QSL via F5CWU.

Please send information about planned future DXpeditions to w9ae@amsat.org. 🌐



Portable Antennas Available for DXpeditions

This portable AO40 antenna system packs into a 25x25x7 inch box and was used in 2003 in Guadeloupe, Lesotho, Swaziland and Belize. Contact W9AE if you wish to borrow it for an AO40 expedition.



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AO-40 BIRTHDAY BASH!

by Bruce Paige, KK5DO • kk5do@amsat.org
AMSAT VP - User Services & Awards Manager

Here are the results of the AO-40 Birthday Bash. There were a lot of participants, however, only a handful bothered to submit their logs for scoring. The results are shown below. The winners and runner-ups will each receive a certificate from AMSAT to their Callbook address. The score between the winner and runner up was really close. Eleven logs were submitted via ASCII email attachments and two were sent via postal mail. (Take a look at the AMSAT Winner's certificate also shown below! – Ed.)

Look for the 2004 Birthday Bash!

Worldwide:

LY3BH	354	Winner
JA1CG	341	Runner-up
UR5MGW	220	
W0EEC	187	
W6ZQ	157	
WD4FAB	68	
RA4CBY	42	
5B4AZ	41	
SV1AWE	40	
JA6BX	28	
N5ZNL	23	
VK5DG	21	
VE2DWE	11	

Stateside:

W0EEC	187	Winner
W6ZQ	157	Runner-up
WD4FAB	68	
N5ZNL	23	

Non-Stateside:

LY3BH	354	Winner
JA1CG	341	Runner-up
UR5MGW	220	
RA4CBY	42	
5B4AZ	41	
SV1AWE	40	
JA6BX	28	
VK5DG	21	
VE2DWE	11	

AMSAT-NA Members:

W0EEC	187	Winner
W6ZQ	157	Runner-up
WD4FAB	68	
JA6BX	28	
N5ZNL	23	
VE2DWE	11	

AO-40 Birthday Bash Winner's Certificates
Awarded to Emily Clarke, W0EEC
and Haruo Takahashi, JA1CG
Congratulations!

Recent Satellite Awards:

Congratulations go out to those that have recently made their very first satellite QSO. May they have many more years of fun on the satellites.

Bob Koulouris, SV1SWE

Glenn Graf, KB1GUE

Congratulations go out to all of the following for earning their Oscar Satellite Communications Achievement Award.

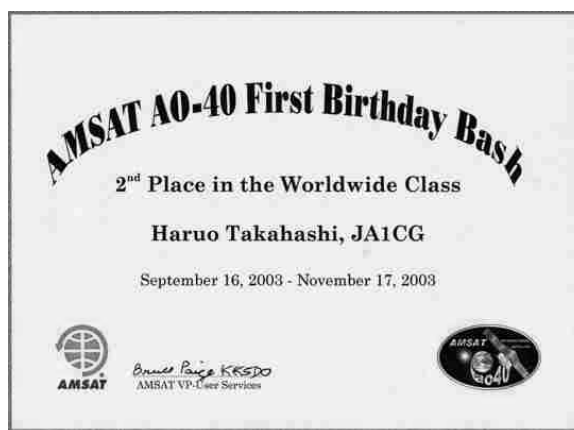
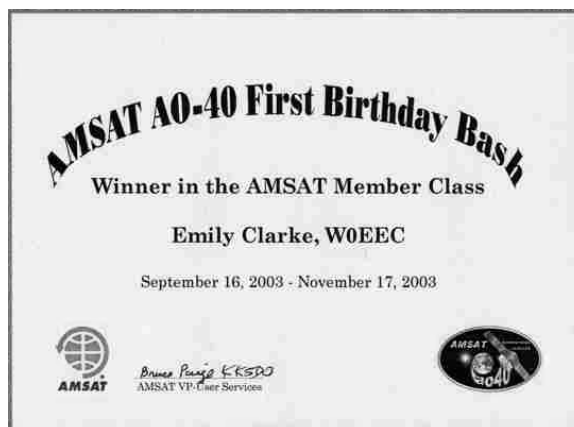
#391	KB1GUE	Glenn Graf	01-Jan-04
#392	N9KQQ	Ted Carlson	07-Jan-04

Congratulations also go out to the following for earning their South Africa Communications Achievement Award.

#US79	N9KQQ	Ted Carlson	4-Jan-04
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And finally, congratulations to Emily Clarke, W0EEC, for earning her 3,000th endorsement to the W4AMI award and to Karl Sandstrom, K5MAN, for earning his 5,000 W4AMI certificate number 16.

To see all the awards and a list of those earning the awards, visit <http://www.amsatnet.com/awards.html>



AMSAT Phase 3 Express: Eight Months After the Kickoff

by Frank Sperber, DL6DBN/AA9KJ

This article first appeared in the September/November 2003 issue of the AMSAT-DL Journal

Translated from German by: John J. Bubbers, W1GYD

Less than two years remain until the planned launch date of the P3E-satellite. The work has to proceed in high gear to stay on the tight time schedule. A lot of new technology, which is planned for the P5A Mars mission, will be tested on P3E. There are many areas of intensive work proceeding even though a completed satellite is not yet to be seen.



Figure 1 (above): The P3E tank is being welded.

Figure 2 (below): Three tank sections form two chambers for the apogee motor's fuel.

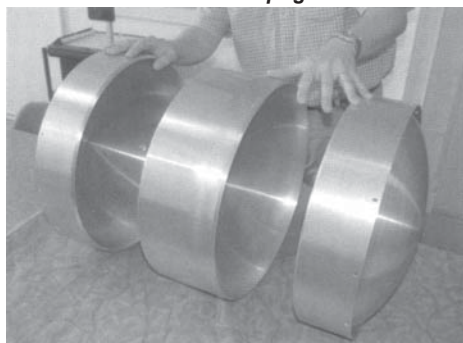
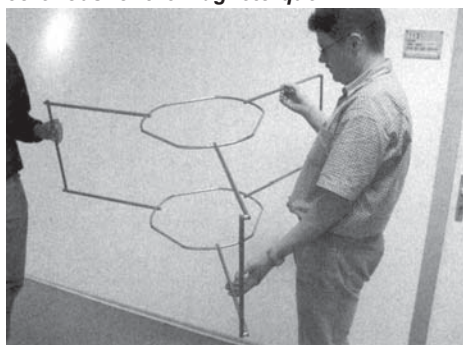


Figure 3 (below): The completed frame of core rods for the magnetorquer.



Mechanical Preparations

Keeping their own integration room in Marburg from the AO-10 and AO-13 construction era (which took place in the USA) has been rewarding for AMSAT-DL. The AMSAT-DL large integration room is the central and major area for the mechanical work on this new satellite structure. A large room is a prerequisite for the integration of the electronic modules. The core assembly of the flight structures consists of a surplus structure from the construction phase of P3B and P3C, which was used as a display unit at fairs, etc. The short construction time for this new satellite is possible only because this structure is on hand. The structure was cleaned and will receive a space-qualified coating. The time saved by having this structure on hand permitted a variety of additional components to be built. Among others that have been constructed are the sun and earth sensors.

The satellite's propulsion system will be coming from Astrium. The fuel for propulsion will be contributed by AMSAT-DL. It has been built (Figure 1), partially tested and is currently at Astrium for final pressure testing. The tank consists of three pieces (Figure 2). Two of the chambers shown will be for fuel. An additional part of the propulsion system is the helium pressure tank, which must withstand several hundred bars of pressure. Several suitable pressure flasks were found for this application. The final decision as to which flask will be used must still be decided based on the available space on the satellite and several technical parameters.

The magnetic attitude control is an important part of the satellite system. It is composed of multiple iron rods, several of which are fitted with electro-magnetic coils. The satellite can be oriented at perigee by controlled energization of the coils utilizing the earth's magnetic field to affect torquing. As seen in Figure 3, the system is close to being finished. Since a few of the materials from the P3B/C era were no longer available, various changes had to be made in the details. Konrad Müller and Peter Osswald completed the mechanical work (Figure 4).

CAN-Bus Ready for Installation

The CAN-Bus, well known in the automotive and other industries, will replace the expensive cabling used on previous satellites. Besides a weight saving by using less cabling, the connections between

modules will be simplified. Such a basic change requires extensive engineering preparation. The requirements of the experimenters and designers, whose modules are going to be connected to the CAN-Bus, can be addressed in various steps and prototypes. In the meantime, the hardware of the small "CANdo!" interface board is located between the CAN-Bus and the module (Figure 5). (See the November/December 2003 issue of *The AMSAT Journal* for more information – Ed.)

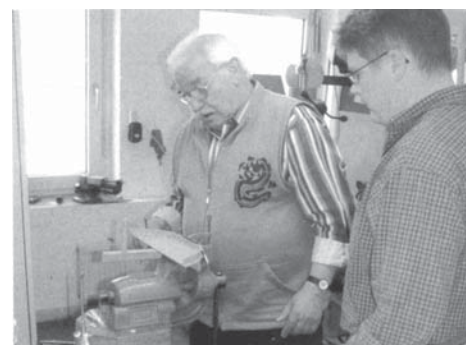
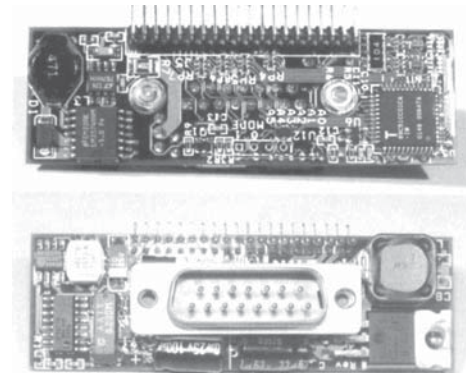


Figure 4 (above): Konrad Müller (l.) and Peter Osswald aligning the magnetorquer's rods.

Figure 5 (below): The individual modules are connected to the CAN-Bus via the CANdo! Interfaces.



The CAN-Bus will also be installed in the Eagle-project as well as in the P3E and P5A. As a result, nearly 100 modules will be needed in the coming years. The hardware development took place by our American friends Lyle Johnson and Chuck Green. First delivery of these modules to the experimenters in Europe is expected to happen near the time this Journal appears.

The "CANdo! widgets", fitted with their own micro-controllers, are valueless without software. A team lead by B'dale Garbee is developing the software. It provides for various communication modes between the modules and the CAN-Bus. In the direct

mode there are five analog modes available and eight digital outputs available. Telemetry and binary states can be managed this way – for example, switching operations in the module. Control of the digital outputs will be used to control external multiplexers in the multiplex mode. This increases the number of signals to and from the module by a large factor. The so-called “byte-pipe-mode” will swap many bytes from time to time from the memory of one of the provided cameras. The on-board computer, the Integrated Housekeeping Unit (IHU), can read and further process the raw data from the CAN-bus. A further mode will probably be added, a serial pipe mode. The on-board integrated controller, in addition to the CAN-Bus, can also feed normal asynchronous level signals. Modules with “self intelligence”, i.e., with their own individual computer, can be connected simply. Cameras could also be considered as scientific payloads on P5A, for example.

The sensor electronic unit (SEU) is one of the modules that will utilize the multiplex-mode. It processes the signals from the classic sun and earth sensors for the on-board computer and controls the magnetorquer. Ulrich Müller is currently developing a version that is adapted to the innovations in the CAN-Bus, based on the AO-10 and AO-13 circuitry (P3B and P3C).

P3E's “Eyes”

After the positive experiences we have had with orbital cameras, especially those from the navigation related YACE camera onboard AO-40, it soon became clear that P3-E should have a similar system. The available optical navigation of star constellations is very important to us in determining the flight attitude and flight path during the Mars mission. A similar navigation system with the STAR-module is to be installed on P3E. The development work is taking place under the coordination of Chuck Green in Arizona. Two camera sensors are being considered, which can view from the upper and lower satellite sides and they will have their own computer for picture evaluation. The Belgian company FillFactory provided suitable newly developed type STAR1000 CMOS sensors. They have a resolution of 1024 x 1024 pixels (four times that of YACE) and are radiation hardened for space use.

A second camera is being developed under the guidance of Peter Gülzow, which uses a completely new chip of the IBIS line, which is also from the FillFactory. These building blocks have extensive electronics along with an image sensor, which naturally stores pictures and can further deliver pictures via

different circuits. An IBIS camera could result in several memory building blocks that will be available to the CANdo! interface. This also means further simplification, fewer building blocks and thereby fewer possibilities for failure. Both cameras operate in black and white. This is meaningless for the STAR sensor, but for the IBIS camera, color images would provide a more interesting look at the earth. This chip will possibly be available as a color sensor by the time of integration.

IHU-3

A new concept was developed for the on-board computer and the IHU after the successful results of the FEC techniques for AO-40 and with the requirements of the Mars mission.

The low bit-rates (5 bits/s) that have to be invoked in an emergency cannot be effectively processed by classic hardware demodulators, which scan the command receiver's passband. With integration times of about 1 second and 1 Hz resolution, a 3000 Hz wide passband would take 50 minutes to be read. This is far too long for an effective command operation. The computing capabilities of the new IHU processor with its ARM7-Basis make digital signal processing possible. Using a Fast Fourier Transform the passband can be read more quickly as it appears to the processor in parallel form.

On earlier satellites the hardware demodulators could reset a program crash by the on-board computer. This will no longer be possible with the new method. The DSP software function will also be required to perform an extreme reset function. In the possible event of a computer crash the computer must reliably rescue itself. Karl Meinzer has developed a Watchdog mechanism, which is controlled by several levels of the system software. If the control remains off or the bit stream is completed without error, an appropriate reset will be invoked.

If the error repeats itself within a given time span because the program memory has a permanent error, the operating system software will automatically be switched over to another backup image, for example.

Lyle Johnson and Chuck Green are reviewing the functional design of the new on-board computer and are thereby developing the third generation of the P3 satellites. There is also the opportunity to develop an IPS32 operating system since this IHU is based on a 32-bit processor.

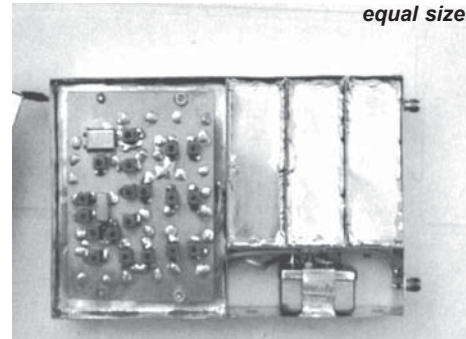
U/V Prototype Transponder Tested

On July 5th William Leijenaar tested the first prototype transponder for 435 MHz as the payload on a balloon launch in Meiningen (Figure 6). Signal reports indicated a strong and clear beacon signal from the 100-mW transmitter. Unfortunately a lot of transmitter power had to be used to hear the signal through the 100 kHz wide linear transponder. In retrospect it turned out that apparently there was a problem in the cabling between the temporary band switch and the receiver. The transponder, which is mainly made up of SMD parts, needed only a housing area of only 100 x 160 mm (Figure 7).



Figure 6 (above): The U/V transponder prototype before the balloon launch.

Figure 7 (below): The U/V transponder: The transmitter board is on the left, the 70 cm input filter is on the upper right and the IF filter is on the lower right. The rear half of the assembly contains the receiver board of equal size.



The 145 MHz output stage from Konrad Hupfer is likewise operational. It delivers about 70 W PEP with 10 mW of drive. Using HELAPS (Highly Efficient Linear Amplification by Parametric Synthesis) technology, the operational level of the output stage will be raised to 50 W PEP without negatively affecting the energy budget. Signal levels similar to those from AO-10 and AO-13 can be expected, as a result. HELAPS technology will also be used at 145 MHz and 2400 MHz. Danny Orban and his team will take over this effort. A meeting has taken place in the meantime in Marburg for knowledge transfer.

New Territory with the P5-Simulator

Karl Meinzer and Matjaz Vidmar have made several steps forward with the basic designs for a coherent P5A transponder that will simulate the link paths to Mars. AMSAT enters its own new territory with this transponder. In addition, communications "ranging" must be possible between earth and the satellite to accurately determine the distance to the satellite using a given transit time measurement to accurately determine the distance to the Mars radio-sonde within a few kilometers. A further increase in the accuracy of position determination would then be available.

The P3D transponder should be operated as a linear transponder on modes L/X and S/X. To receive sufficient signals in normal radio operation the transponder will be fitted with an output stage and a parabolic reflector. A group under Michael Fletcher in Finland is currently constructing the output stage.

Wolfgang Müller has supported the major problem of precise frequency control. Professionally he is occupied with high stability oscillators. At the low bit rates of 5 bits/s, which could at times be necessary, the oscillators must generate very little phase shift. Only then can longer integration times of the weak signals be possible. This will be achieved with the ultra stable oscillator (USO) provided. As a secondary effect the other oscillators can lock onto the USO as the need arises. This is already in accord with the preliminary design of the L-Band receiver by Mirek Kasal.

A Closer Look at 24/27 GHz

The originally proposed transmitters for 24 and 27 GHz have turned out to have a problem. Global illumination would not be possible with the desired link budget and the proposed antennas. A spot beam with about a 6,000 km footprint would only be possible on the earth's surface and for 47 GHz only about 3,500 km. These spot beams would traverse at the apogee for only 30 or sometimes 15 minutes. It would have been more reasonable with a spin-stabilized satellite, as it will be with P3E.

We hope that it will be possible for the developers of these transmitters, Freddy Guchteneire and Michael Kuhne, to achieve a larger viewing angle to achieve global coverage, without noticeably worsening the radio link. Such a signal reduction would increase the cost of the ground stations in relationship to the antenna gain and positioning accuracy required.

P3E on ARIANE 5

The launch configuration has not been finally decided. The AMSAT-DL proposal to use the proven and known Satellite Bearing Structure (SBS) for P3E as well as P5A has been found to be very interesting at Arianespace. However, because of the increased payloads on the newer Ariane 5, further modifications are needed for the SBS. Arianespace is currently asking if the

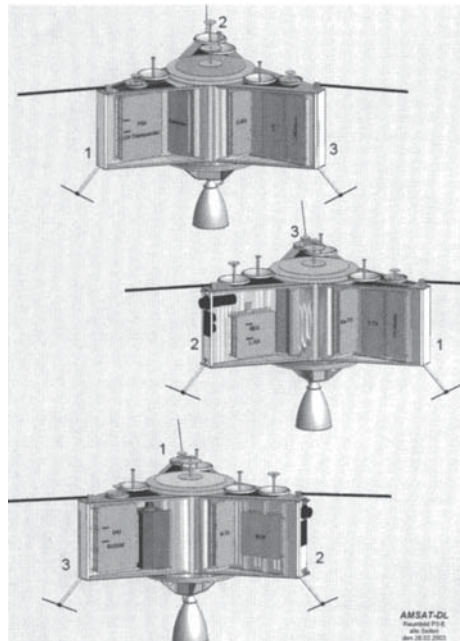
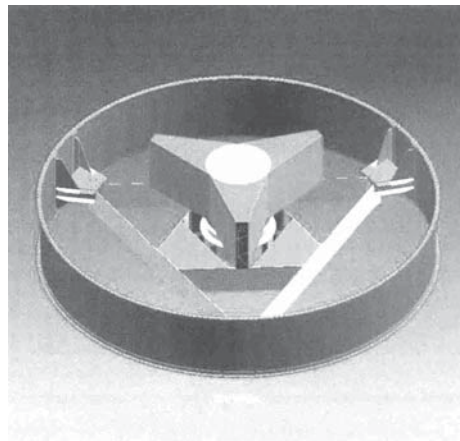


Figure 8 (above): A view of P3E's three side arms.

AMSAT developed SBS technology might be further developed as a permanent possible launch option for other future loads. In any event, for P3E it is independent of whether AMSAT-DL or Arianespace will make an SBS ring available or an auxiliary table becomes necessary that functions as an adapter between the three mounting points in the SBS and the smaller, round separation interface of the P3E. Robert Knoblauch has made a design (Figure 9) and has found

Figure 9 (below): P3E on the adapter plate mounted in the SBS.



sources for making the table. The SBS could also be made there if needed.

P3E Time Schedule

Although several items, such as the propulsion system, the solar cells and the transponder area have not yet been finalized, the tight time schedule of launch in 2005 has until now been maintained. The goal is now, as before, to be able to fully test the satellite in the second half of 2004.

In closing, once more we address our appeal to participate in contributing to the P3E project. Donations can be made online on our Internet site at:

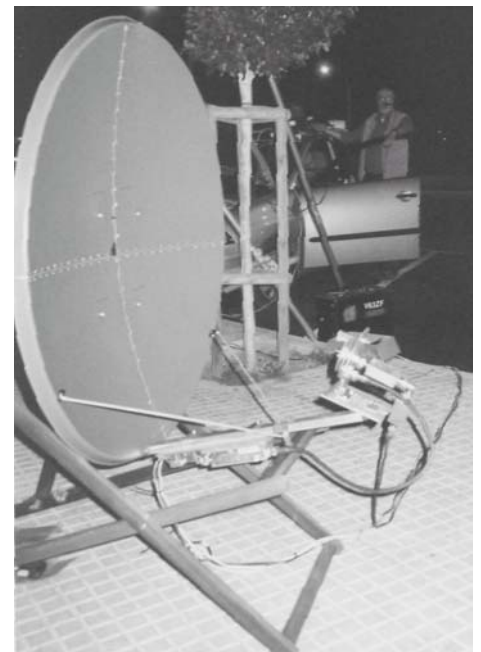
<http://www.amsat-dl.org/p3e/>

Many thanks because only with your help will P3E find its way into orbit! 🌐



Please support AMSAT-NA
Thanks!

SATELLITE DX - BRIEF



Rolf Niefind, EA6/DK2ZF, in Mallorca conducting a field trial of his new AO40 mode L/S portable antenna. His operating "shack" was on the roof of the car. The 1.1m dish separates into four pieces and will be used during his upcoming multi-island Pacific expedition.



ALON/ALAT Determination of AO-40 and the YACER Software Package

by Reinhard Richter, DJ1KM

*This article first appeared in the September/November 2003 issue of the AMSAT-DL Journal
Translation from German by: John J. Bubbers, W1GYD*

As is already well known, the attitude of AO-40 has to be controlled and regularly corrected so that the satellite receives enough sunlight to generate energy and so the antennas can be aimed at the earth. Both requirements don't always match, as we have found out from the past. The constantly changing sun angle requires turning the satellite far enough so the solar cells are pointing at the sun. But the antennas can, under some circumstances, not point toward the earth. We have already often experienced these so called "sleeping times"; the last period was from the middle of April

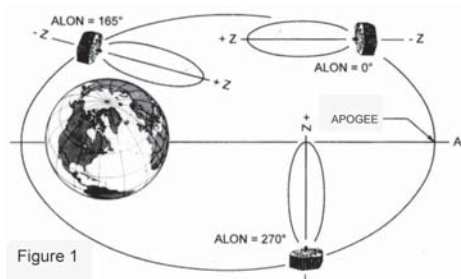


Figure 1
Graphical depiction of ALON

2003 until the second half of May and then during December. To refresh our memories, ALON and ALAT are the angular values of the satellite's axes. Frank Sperber, DL6DBN, has fully explained this in his Mini-Glossary, which was printed in the February 2001 issue of the AMSAT-DL Journal and can be found on the website of AMSAT-DL. ALON and ALAT are fully explained in the following.

"ALON stands for Attitude LONgitude, that is the longitude of the flight attitude. The reference axis is the major half axis that connects the perigee (the point closest to the earth in the orbital path), the earth's center point and the apogee (the furthest point from the earth). The reference point is the apogee and the computed direction, which is in the same direction as the satellite's motion in the orbital path. ALON indicates values between 0 and 359, or how the Z+ axis is located relative to the half axis. For instance, ALON = 0 means that at the apogee the antennas are pointing in the direction of the earth, while ALON = 180 they are pointing toward the earth at the perigee." (See Figure 1.)

"ALAT stands for Attitude LATitude. That is the latitude of the flight attitude of the satellite. The reference plane is the orbital

plane of the satellite. The latitude value ALAT indicates how the Z+ axis of the satellite points out of this plane. Positive values indicate an inclination toward north, and a negative value an inclination of the axis toward the south. The primary radiation pattern of the antennas is in the Z+ axis. The closer ALAT approaches 0, the better the antennas are directed toward the earth's center in the north/south direction." (See Figure 2.)

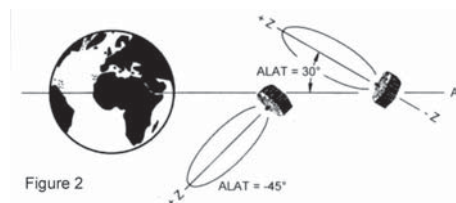


Figure 2
Graphical depiction of ALAT

ALON and ALAT are responsible for determining the squint angle, as Frank Sperber explains as follows in the Mini-Glossary:

"The squint angle or off-angle indicates how much the satellite's main-directional antennas point away from the observer. A squint angle of 0 indicates that the satellite's antennas are optimally oriented toward the ground station. The gain is maximized and

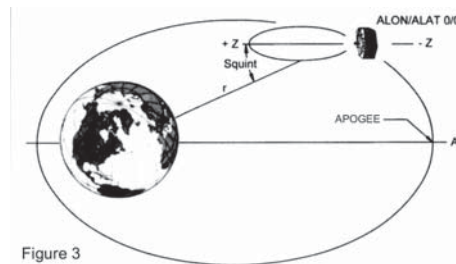


Figure 3
Graphical depiction of Squint Angle

the spin effects are minimized. The higher the squint angle, the poorer is the satellite's audibility. At a 90-degree squint angle the satellite is observed from the side, and at 180 degrees the satellite is viewed from the rear." (See Figure 3.)

The satellite is spin stabilized, that is, it maintains its attitude in space by gyroscopic action of the satellite's rotating motion, until the attitude is changed by outside forces. The

magnetorquer serves this function as Frank Sperber explains in the Mini-Glossary:

"There are several electro-magnets distributed in the satellite, also called the magnetorquer, that can be used in conjunction with the earth's magnetic field in the vicinity of the perigee for attitude control of the satellite. The satellite functions as the rotor of an electric motor while the earth's magnetic field presents the stator. This control process is called magnetorquing. The flight attitude and the spin rate of the satellite can be changed using magnetorquing." (See Figure 4.)

Accordingly the attitude would seldom have

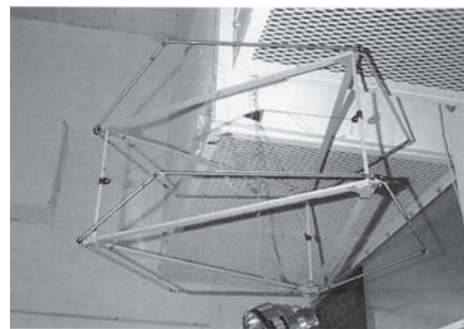


Figure 4
Magnetorquing structure

to be modified. Only when the sun's angle becomes poorer is action taken to turn the satellite into the sunlight and then to return it, to point the antennas toward the earth. Soon after the launch it was noticed that there was an effect that changed the satellite's attitude without any input from a command station, so that daily manual corrections were required. This effect was called "mystery effect" because it was mysterious and unexplained. Eventually an explanation was found.

The permanent magnets of the, until now, unused reaction wheels display a magnetic field that likewise produces a magnetic effect on the satellite in the vicinity of the perigee. This effect changes its attitude. The need then arose for the command stations to manually control the attitude. It appears now that for the life of AO-40 the command stations will be employed to correct this effect. A description follows of how the command stations acquire the current attitude of the satellite, and then on how the attitude changes are carried out with the acquired values.



This is a very exciting story and interested radio amateurs can retrieve the proceedings. Gunther Meisse, W8GSM, took the trouble to assemble all of the software programs used by the command stations for this purpose. He created documentation and with its help one can calculate the ALON/ALAT values. The images from the YACE camera (Figure 5) on the satellite, transmitted via telemetry to earth, serve in the first instance. Gunther Meisse calls the project "YACER" (Yet Another Camera Experiment) R (Revisited)". I have translated the documentation into German with the additional help of Gerd Riesner, DB3DH, and the software package with German documentation is available on the AMSAT-DL website under in the "download" section. The different Windows based programs were originally developed for the members of the

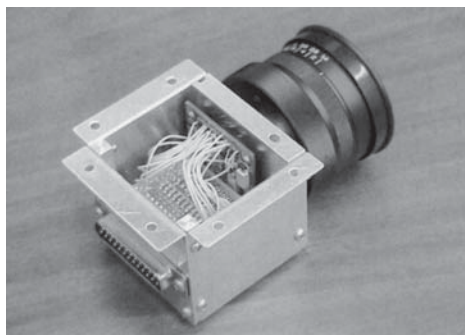


Figure 5
YACE CCD Camera

AO-40 command team. The programs in the package contain special versions of the command functions that make it possible to determine correct ALON/ALAT values, and especially with the help of images that are downloaded from the YACE camera. The YACE camera was installed to capture images of the AO-40 separation from the carrier rocket. The complete series of these pictures can be seen on the AMSAT-DL website. One image will be shown here.

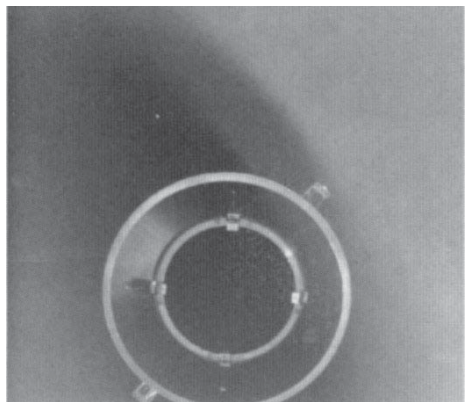


Figure 6
AO-40 separation photo

YACE has become a valuable navigation instrument, and using it, AO-40 can be maintained in a stable attitude. This tool delivers images of the earth and moon and verifies the computations and calculations of the parameters necessary to determine the ALON and ALAT of AO-40.

The various command programs were developed and improved by Stacey Mills, W4SM, for the Windows platform, and for the Acorn/RISC platform by James Miller, G3RUH, during the many years of Phase 3 missions on AO-10, AO-13 and now AO-40. The YACER program package is contained in a ZIP file, which completes the installation on a computer after being unzipped. Attachments to the directory \YACE are created for all programs, which can simply be moved onto the desktop.

[Drive]: \YACE\ConvKeps
 \YACE\AttPlot
 \YACE\Despin
 \YACE\Dump
 \YACE\Dump\ Orbit 992
 \YACE\PlanSat
 \YACE\SpinFit

[Drive]: \WinKeps
 \WinKeps\Files
 \WinKeps\Keps\Original INI

To better understand what the command station has to do to get the ALON/ALAT values the following procedures will be described:

- Supply the newest Keplerian elements.
- Run CONKEPS to bring the Keplerian elements for the G3RUH element statements to the newest level.
- Run ATTPLOT to determine the start times of the image sequences, the number of images and the image intervals.
- Send commands to the YACE camera to take pictures, and then to download the .jpg images as "D" block on the telemetry beacon.

After the related telemetry information (D-blocks) have been downloaded from the AO-40 beacon:

- Run SPINFIT to determine the spin rate of AO-40 from the telemetry file Annnnn.tlm
- Run DUMP to extract the related images from the telemetry file Dnnnnn.tlm. The received pictures have the format hhmssdd.jpg, wherein hh = hour, mm = minute, ss = second and dd = one tenth second.
- Run DESPIN to remove the distortion due to the spin with the help of the spin rate number, and to determine the angle between the turning axis of the satellite and the Earth's edge (and/or that of the moon).
- Prepare the data and input for input into the ao-40.ang file

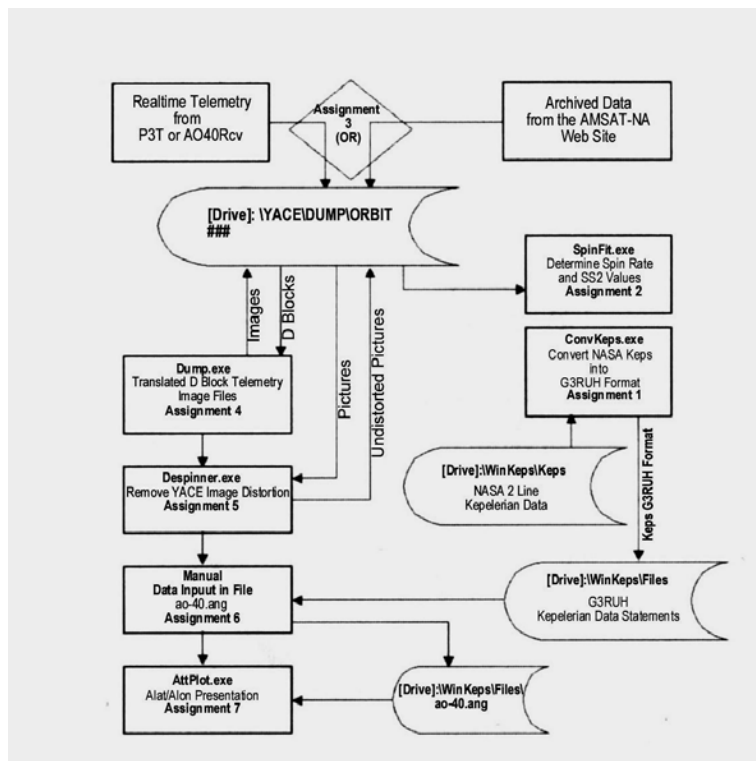


Figure 7
ALON-ALAT calculation procedure

- Run ATTPLOT to determine ALON, ALAT and the sun angle (generated in ao-40.ang).

Document the data and move it into the AO-40-archive.

If the YACER program is fully installed and functional, to determine the satellite's ALON/ALAT you will experience practically the same process.

The flow diagram (Figure 7) clearly shows the steps to determine the ALON/ALAT.

The program package makes it possible to repeat the work in its entirety of the command station, or copy the attitude data (Orbit nnnnnAtt.txt) that have been stored in the telemetry archive and then use ATTPLOT to look at the completed results.

If you want to retrieve data from the archive, go to the Internet URL:

www.amsat.org/amsat/ftp/telemetry/ao-40/.

Select an archive data file, which is noticeably larger than the others are. This contains a nnnnnJPEGS.zip file in which nnnnn indicates the orbit number. In it there are several images recorded by the YACE camera such as in the following example. The earth is seen from the satellite's viewpoint. There are also images in which the moon is recognizable. The image quality is not very good, because the camera's lens was somewhat degraded during the event in December. The quality is sufficient for the determination, however (Figure 8).

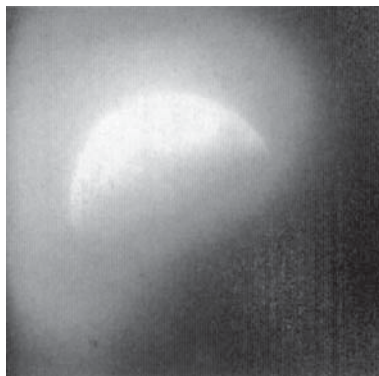


Figure 8
Earth photo from the YACE camera

The DeSpin software will then process this image, since, during the exposure, distortions were introduced by the spin of the satellite. A resulting image will then appear as in Figure 9.

An angle value will be produced in a further processing level. All of the received images in the ZIP file will be processed and the data collected and will then at last lead to a final result. (See Figure 10.)

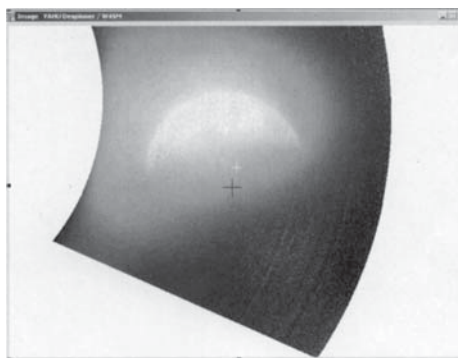


Figure 9
Earth photo after de-spin processing

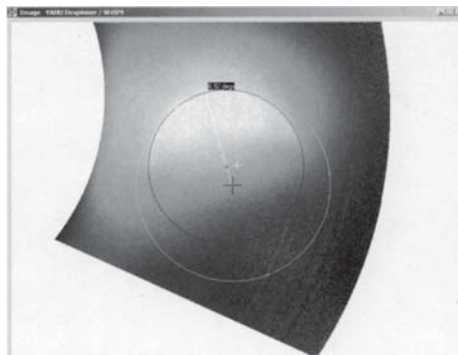


Figure 10
Result after final de-spin processing

In the course of the processing, several Plot images will be generated, which will give the final value of the sought after ALON/ALAT. Since April 2003 the current values have been shown in the status window of the AO-40 telemetry (Figures 11, 12, and 13).

The details of further processing cannot be shown here for understandable reasons. The German YACER documentation package deals with this extensively.

The concept and aim of this presentation is to show the extensive work that the command stations have performed, which makes it possible for us, the "Users", to use the satellite for QSO's. The hams of the command team cannot be thanked enough for their ongoing and tireless work.

This should be further encouragement to undertake the evaluation of ALON and ALAT from the data at hand and with the YACER software package, and so, to further attain an understanding of the relationships.

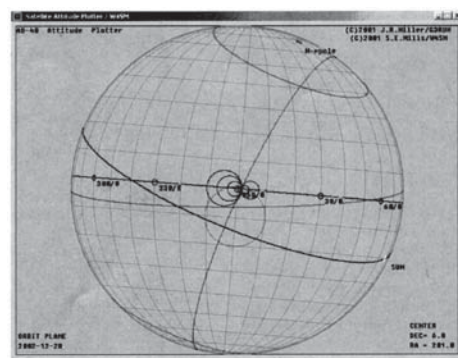


Figure 11
Telemetry status window

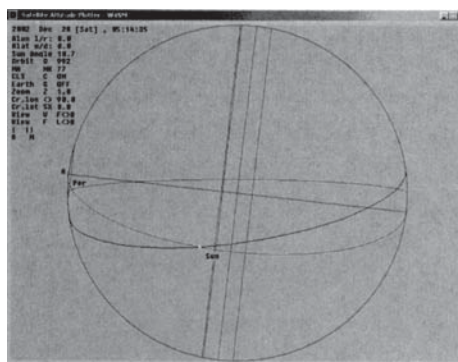


Figure 12
Telemetry status window

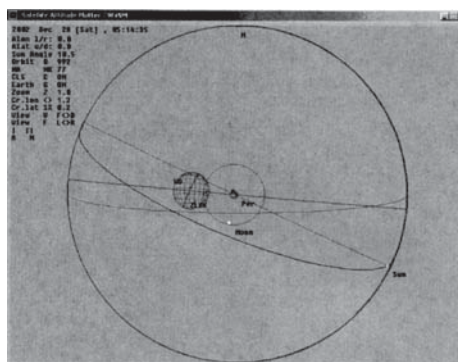


Figure 13
Telemetry status window



What Does Circular Polarization of the Antenna Add to Satellite Operation?

by Franz J. Bellen, DJ1YQ

*This article first appeared in the AMSAT-DL Journal September/November 2003/2004 Edition
Translated from German by John J. Bubbers, W1GYD*

Introduction

Much has already been written about this subject, so a detailed explanation will not be provided here. Therefore a short comment:

If the satellite signal has circular polarization, then the maximum field strength signal will be received using a similarly polarized receiving antenna, while signal strength with a linearly polarized antenna would be, theoretically, 3 dB less. This is valid if the antennas are aligned with each other, i.e., the squint angle is 0 degrees. If the receiving angle is > 0 degrees, the conditions are indeterminate. The writer has examined AO-40's beacon signal at different squint angles with a linear and a circular polarized antenna to shed some light on this gray area.

Test Arrangement

The long Yagi antenna, with 67 elements from SHF Electronic on hand at the writer's QTH with a gain of 20 dBd, is well-known in the amateur community and does not have to be described further. The antenna signal is fed to a UEK-2000 downconverter via a short cable. This arrangement has a noise figure of 1.1 dB (cable: 0.1 dB, converter: 1.0 dB).

The SSB-Electronic company, Iserlohn, made a parabolic reflector with a circularly polarized patch driven element (a special model) available for the tests. This antenna, Airlink Model 60, is an industrial model and is hardly known in the Amateur Radio community (see Photo 1). This is a very

lightweight plastic antenna that has a copper film reflector surface and stainless steel mounting clamps. This execution represents the typical industry standard. The antenna is weather-tight because of its encapsulation and has low wind resistance because of its shape. The parabola's diameter is 620 mm, and the f/d ratio is 0.3. The indicated gain is 22.2 dBi, which is comparable to that of the Yagi. This model series is linearly polarized and is used in terrestrial LAN networks.

The antenna signal is fed to a UEK-3000, $F = 0.6$ dB, via a connecting cable, $F = 0.3$ dB. The total noise figure of this arrangement comes out to 0.9 dB, somewhat better than the Yagi arrangement.

The beacon signals from AO-40 and the noise were recorded one directly after the other with the receiver arrangement for 100 seconds. It is assumed that during these 200 seconds no substantial signal changes took place.

The hardware and software for the measurement recording was extensively described in an earlier reference¹.

Measurement Results

Definitions

Average value means: The sum of the measurement values divided by the total number of measurement values, 1000 in this measurement. The "Standard Deviation" (sigma) is a statistical concept which means that 68.3% of all measurement values lie

- The beacon signal with the parabolic arrangement
- The beacon signal with the Yagi arrangement
- The noise of both receiving systems
- Interesting satellite parameters were noted at the same time.

The average value of the attendant noise was subtracted from the appropriate individual beacon signal value to evaluate the beacon signal ratio. The usable signal amplitude is the difference between the average value of the beacon and the noise signals.

Results

Three typical measurement categories were chosen for the performed tests. The noise measurements from all of the measurements that the parabola/UEK-3000 had a standard deviation of 1.0 and the Yagi arrangement had a sigma of 1.1 dB. This is covered by the noise figures, see above. The usable signal levels of both systems differentiate themselves by less than 1 dB in all of the tests. Its absolute magnitude is seemingly dependent on the range to the satellite.

Discussion of the Results

Figures 1 and 2 show that a linearly polarized antenna delivers an equally good result as a circularly polarized antenna at small squint angles up to 10° . Sigma is equal, when the measurement values are in the level of 2.7 dB = 22% based on a signal level of 12 dB.



Photo 1

Parabolic reflector with circularly polarized patch driven element (Airlink Model 60) for SSB-Electronic

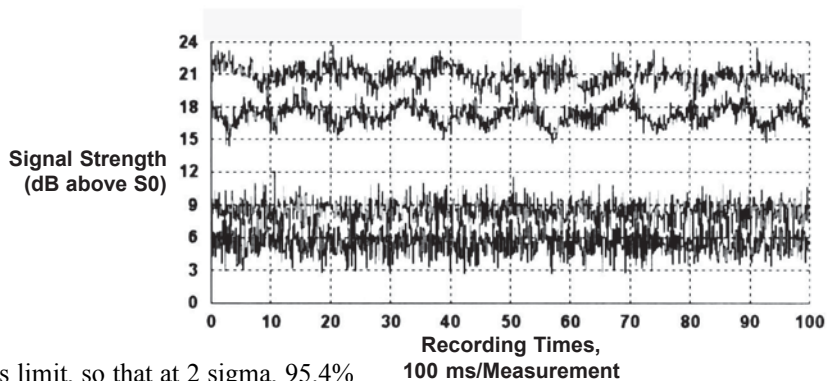


Figure 1

Raw Data Received on 02Mar03
from bottom to top:
Noise - Yagi, Noise - Parabola,
AO-40 Beacon - Yagi,
AO-40 Beacon - Parabola
Satellite: MA=183, SQ = 10.8 Degrees,
EL = 30 Degrees, AZ = 170 Degrees,
D = 53,000 km

within this limit, so that at 2 sigma, 95.4% are within the limit and at 3 sigma, 99.7% of all measured values are within the limit. It is reasonable to use 3 standard deviations for amateur purposes, when considering the depth of signal variations.

For each test four sets of measurements were made each with 1000 measurements, with a cycle time of 100 ms, and more specifically:

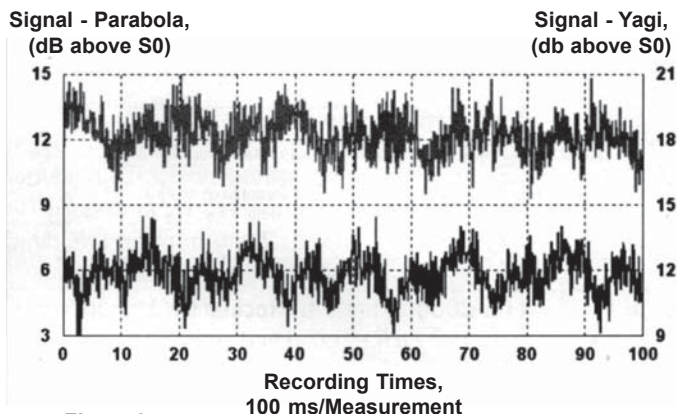


Figure 2
Evaluation of the Beacon Signal from Figure 1:
 Parabola with UEK-3000 (upper),
 Average value 12.2, Standard deviation 0.9 dB
 Yagi with UEK-3000 (lower),
 Average value 11.8, Standard deviation 0.9 dB

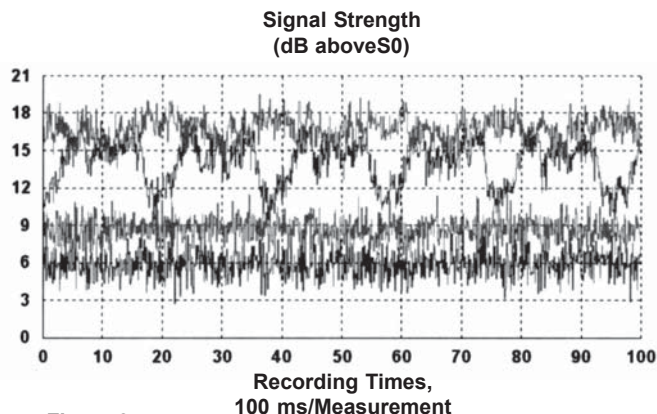


Figure 3
Raw Data Received 03Mar03 (from bottom to top)
 Noise - Yagi, Noise - Parabola, AO-40 Beacon - Yagi,
 AO-40 Beacon - Parabola
 Satellite MA = 133, SQ = 23.7 Degrees, EL = 29 Degrees,
 AZ = 183 Degrees, D = 61,100 km

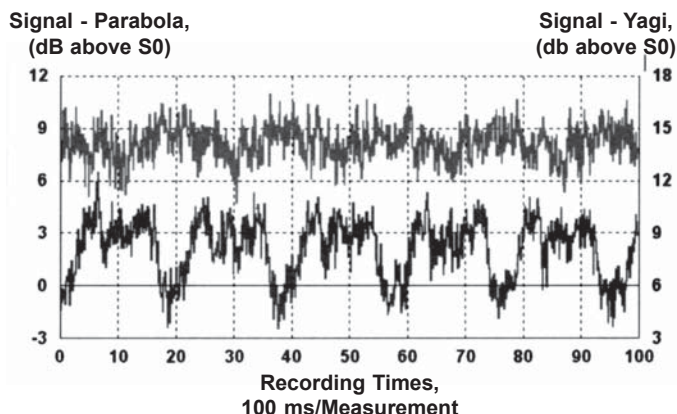


Figure 4
Evaluation of the Beacon Signal from Figure 3:
 Parabola with UEK-3000 (upper),
 Average value 8.1, Standard deviation 1.0 dB
 Yagi with UEK-3000 (lower),
 Average value 8.1, Standard deviation 1.7 dB

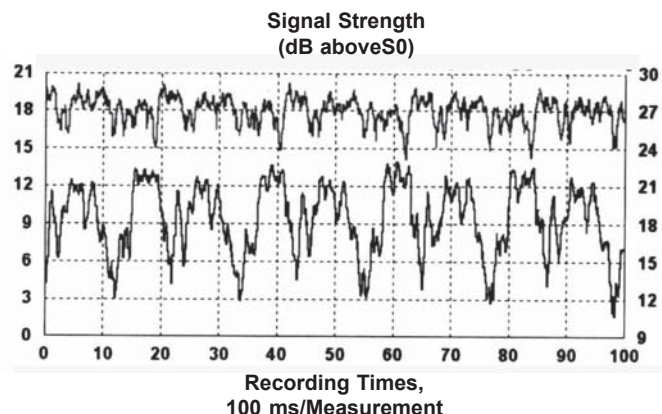


Figure 5
Raw Data Received 01Apr03 (from bottom to top)
 Noise - Yagi, Noise - Parabola, AO-40 Beacon - Yagi,
 AO-40 Beacon - Parabola
 Satellite MA = 242, SQ = 33.4 Degrees, EL = 27 Degrees,
 AZ = 160 Degrees, D = 18,100 km

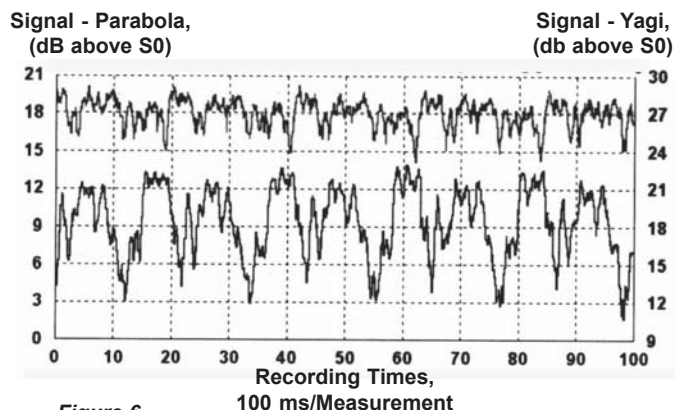


Figure 6
Evaluation of the Beacon Signal from Figure 5:
 Parabola with UEK-3000 (upper),
 Average value 18.0, Standard deviation 1.0 dB
 Yagi with UEK-3000 (lower),
 Average value 18.4, Standard deviation 2.7 dB



At this point the reception of the beacon is satisfactory and SSB communication is possible.

If the squint angle is increased the situation is different. At an angle of 23.7° the beacon signals of the Yagi arrangement lie in a deviation band of 5.1 dB = 63% based on a signal of 8.1 dB, see Figures 3 and 4. The third test (Figures 5 and 6) was performed at a squint angle of 33.4° and at a smaller satellite distance. The signal variation for the Yagi arrangement is now 8.1 dB = 44% at a beacon level of 18.4 dB. At signal variations on the order of 50%, operating on AO-40 becomes problematic.

The conditions are much better for circular polarization. Under the same conditions the parabolic arrangement has a standard deviation of only 1.0 dB, based on the beacon level (3 sigma) of variation of 37 and 17%. The signal changes are reduced by 50%, which also reduces the difficulties in receiving.

Summary

As is often claimed, namely that a circularly polarized antenna is better for satellite operation than a linearly polarized one, has been established here with numerical examples. The disadvantage, however, is the increased wind loading on the parabola over the linearly polarized Yagi antennas. An advantage in this regard is the SSB-Electronic antenna from Airlink. It is not possible, in this case, to connect the antenna preamplifier or the signal converter directly to the patch antenna.

Reference

1. Franz J. Bellen, DJ1YQ, "Erfassung und Auswertung von analogen Satellitensignalen" AMSAT-DL Journal Nr. 1, Jg30, März/Mai 2003

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CQ OSCAR DE 4U1UN

By Ray Soifer, W2RS, w2rs@amsat.org

From *The AMSAT Newsletter*, March 1979

On February 4, 1978, club station 4U1UN, located at United Nations Headquarters in New York City, became a new country on the DXCC Countries List. The UN is understandably concerned about maintaining tight security precautions, so most 4U1UN operation to date has consisted of brief lunch-hour forays by staff members. However, special arrangements have been made for full-time operation of the station during several major DX contests, and it was with this in mind that the North Jersey DX Association accepted an invitation to operate 4U1UN during the 1978 CQ World Wide CW Contest, on November 25-26. The principal objective was to give a new country on CW to as many DXers as possible.

The invitation came about a week before the contest. With a little gleam in his eye, the writer signed on to take the last shift, Sunday from 1700 UTC through the end of the contest at 2400. My operating partner was to be Dave Beckwith, W2QM, a top-notch operator and DXer but one whom the satellite bug has not yet bit. (Are there any left?) Fortunately, however, Dave is a very tolerant soul, and I started to wonder ... might there be any way to get the new country on OSCAR while we were there?

Owing to security restrictions, all operation would have to take place from within the temporary contest operating room, with a UN staff member in attendance who would be responsible to the authorities. There was concern about possible RFI into the UN police radio, which had apparently occurred once before and caused an early QRT. Fortunately, the cause of that episode had been discovered and corrected, but nobody wanted a repetition.

Physically, the operating room was located in a penthouse atop the 39th-story roof of the Secretariat Building. We were informed that the doors to the roof were equipped with alarm devices, and that triggering them would be most unwise. The penthouse itself was about ten feet high and seemed to be made of concrete. It had small windows beginning about eight feet from the floor, looking east and west. From this description, provided by the crew who had operated the phone contest the previous month, it appeared that any OSCAR operation would have to use an indoor two-meter antenna, since the only outdoor antenna available was an 80-10 meter trap dipole which could be used for 10-meter downlink. Using the FT-221 multimode two-meter transceiver at 4U1UN, the phone crew had maintained fair

contact with the North Jersey DX Association repeater, with only a 19-inch whip antenna. Thus, an indoor antenna for OSCAR did not seem out of the question.

Plans were made to bring a portable two-meter dipole and hang it in a window. When this was discussed over the repeater, Leo, W2OEI, volunteered his collapsible two-element beam. Ed, WA2CBB, who was going over to 4U1UN Friday night, volunteered to leave a 50-watt amplifier. Suddenly, things looked a bit brighter. In addition to the contest-type things (keyer, audio filter, etc.), the writer hooked up a 9-volt battery to a Janel preamp in case the FT-101 at 4U1UN needed some help on the downlink.

Friday night at home: A single ring on the telephone, the signal to get on the repeater. Ben, W2BXA, had WA2CBB's wife on the telephone. Ed reported that the FT-221 was not there. Should he leave the amplifier anyway? No, I said, I would bring my trusty old Ameco TX-62, along with an FM hand-held to provide liaison.

Saturday, Joe, W2YY, on the next shift, set up a broom handle in a pipe stanchion to serve as a mast for the two-meter beam. W2QM, my operating partner, who lives near W2OEI, picked up the beam and would bring it with him. I sat down and plotted orbits. Two AO-7 orbits, 18444 and 18445, and one AO-8 orbit 3715, looked possible during the time available, providing of course that they came up in Mode A.

Sunday. Dave and I arrived at 4U1UN, amid a few misgivings about how we were going to get our equipment back out through security. After figuring out how to get a sidetone for keying (the one in the FT-101 wasn't working), we settled down to the pileup. With Dave giving out 59905 reports, (if you got anything else you worked a pirate), I went about setting up the FM link. Trouble. The one-watt hand-held, even with the beam, would not key the repeater. We could hear it, but could not get in. More trouble. In the rush to get going, good old W2 Real Slow had left the OSCAR tracking data home. Still more trouble. The telephone would not dial out on Sundays. Well, we had a radio station going, so I told Dave that the next time he heard an NJDXA member I wanted to talk to him. Sure enough, Hans, W2TO called on 10 meters and Dave passed the key to me. After I explained the problem, Hans got W2BXA on the repeater, and Ben read the tracking data to me on FM while I responded on 28 MHz CW.

At this point, Mr. Ormond Abbott of the UN staff arrived, to be joined later by Max De Henseler, HB9RS/W2, the president of 4U1UN. Were it not for these fine gentlemen, nobody would have worked 4U1UN on OSCAR at all that day. I quickly explained what we wanted to do, and the fact that I was afraid that absorption in the building walls would prevent the OSCAR signal from getting out. Later, Dave found that if he placed the two-meter beam up against the window, we could get into the repeater, but not otherwise. Thus, as long as we were restricted to indoor antennas, we would probably not be able to rotate the beam. Ormond and Max had a solution. On the way in, they had noticed that one of the roof doors was open, and Ormond, who had been with the UN since 1945 and knew absolutely everyone in the place, simply called the security officer in charge and obtained permission for us to use the 39th floor roof, as long as he was there.

Walking outside, we found that building absorption had indeed been the problem; the hand-held was full quieting into the repeater from the roof on its internal whip. We set up the broomstick mast in the pipe stanchion, placed the stanchion on a stool, and the stool on the roof. Presto. Two elements up 400 feet. We were not entirely in the clear in all directions, however, since the penthouse still blocked the west and a high building wall blocked the north. With only 25 feet of coax (enough for the indoor operation that had been contemplated), that was about the best site we could find.

Via the repeater, Jack, W3CWG, reported that Orbit 18443 had stayed in Mode B. With the contest going well at better than 100 contacts per hour, we decided to forego 18444, since that would probably be in Mode B as well. (It was.) Using the outdoor beam, the TX-62 was 599 at W2YY, W2BXA and WA2CBB. With Orbit 18445 coming up, I explained the pointing instructions to Ormond, who had volunteered to be our "Armstrong" rotator, and hooked up the preamp to the FT-101. Murphy's Law. No preamp. No OSCAR either, and we wondered what was going on until W2BXA said via the repeater, which we could still hear, but not talk into from the operating position, that this orbit was in Mode B also. The JA's were beginning to run on 14 MHz, and we went back to that band, knowing that few Japanese had yet worked 4U1UN for a new country on any band. The next orbit, 3715 on OSCAR 8, would tell the story. Via



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hand-held from the cold roof, we mentioned to Ben that if that orbit was in the wrong mode as well, the gang on 3850 kHz (that was the 75-meter AMSAT Net frequency at that time in North America) would get a lot of hot gas from us.

Half an hour (and 50 JA's) later, we said sayonara on twenty and set up for OSCAR 8. Mode J! Stay cool, said the gang on the repeater. Well, we weren't going anywhere, and it was minus ten degrees Centigrade on that roof. At 0109 UTC, eleven minutes after equator crossing, the satellite flipped to Mode A. "We hear you on 29.468!" said WA2CBB on FM. Apart from the beacon, the first signal we heard was W2BXA. QSO. Then W2LV, for his Country Number 96. W1NU for his Number 99. WA2CBB, for

Number 87. All told, we worked eight stations in five minutes before the satellite slipped below the northern wall. After that, we could still hear it but could no longer access it.

As is apparent from this account, 4U1UN via satellite was a collective effort gotten up at the last minute by quite a few wonderful people. This particular nut held the key paddle, but if any of the people mentioned, plus a number of others, had not been there, it could not have come off. In particular, special thanks to K2FC and W2TO for arranging the contest operation. Thank you all, and we'll be back to give 4U1UN contacts to more of those who need it. That is, if the security force ever lets us back on the roof!

Postscript, 2004: I never did return to 4U1UN, although Hans, W2TO, worked several dozen additional stations from there via satellite over the next year or so, and Al, K2UYH, has put it on EME. At this writing, 4U1UN is equipped only for HF and 6m operations, with 100 W to a folded dipole antenna, and is operated only sporadically. It remains an active participant in the IARU HF beacon program. However, due to heightened security post - 9/11, it is very difficult for anyone not affiliated with the UN to gain access to the station at this time. Ormond and Max have since retired from the UN staff, as has Vince, K2FC. W2LV and W2OEK have joined Silent Keys. 🌐



QRP EME on 432?

Yes, if you do have a station running 4 Yagis and 50W, 2 Yagis and 100W, or 1 Yagi and 200W you are capable working HB9Q on CW random! HB9Q (JN47cg) is QRV since April 2000 on 432 and 1296 EME. They are also QRV on 144 EME since 1983. On 432 MHz they have worked (so far) 235 initials, 46 DXCC, 34 maidenhead, 197 grid square, 23 states of USA and WAC July 2002.

On 432 they are using the following station (see picture below):

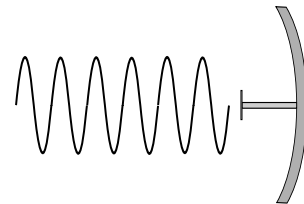
- 15.28m dish, f/d: 0.53, cross-dipole RX: switchable H/V, TX: circular
- 7/8" hard-line by Huber & Suhner
- GaAs FET 0.40 dB NF tuned by HB9BBD
- 8874 by HB9SV, 1000W
- SSB Electronics LT 70 MKII into IC-756 (modified)
- NF Filter: DSP 599zx
- Additional visual DSP by AF9Y (FFTDSP)

In the summer of 2003 they worked on fine-tuning their 432 station getting very good results. During the 2003 ARRL EME Contest they worked 119 stations in 40 multipliers. All QSO's were on random CW. Several stations were QRP!

This are a few examples of QRP stations worked recently:

Call	Antennas	Power (W)	Mode	Comment	On sked
JJ3JHP	4x21el	50	CW		
DL7UDA	4x21el	70	CW	PA was QRT!	
SK6EI	2x28el	100	CW	first EME QSO ever	
A71AW	3m dish	100	CW	first EME QSO ever	X
VK3BRZ	4x15el	120	CW	first EME QSO ever	X
I1PIK	4x31el	120	CW	first EME QSO ever	
PE1ITR	2x28el	180	CW		

Satellite stations and good tropo and contest stations have a fair chance to work them. They are also QRV as JT44/JT65B. They will be QRV during the DUBUS EME Contest March 6-7. Look for them between 432.020 and 432.040. Interested? Contact them at: dan@hb9q.ch . For more information visit www.hb9q.ch .



The radios used normally have a range of about 25 miles, but that range will be extended to about 500 miles at the peak altitude. Two video cameras are used to alternately show the balloon and the horizon. At the peak altitude, the curvature of the earth is visible. APRS packets transmit the balloon's location about once a minute.

NTBP's Doug Howard said, "This is being done mostly for fun. It involves many different facets of Amateur Radio and thus a project that many types of Amateur Radio operators can enjoy together. There is also an educational component utilized by scouting groups, because it involves orienteering and can be counted toward several different merit badges, as well as by teachers for science experiments." According to Howard, Boy Scout troops from Fort Worth and Benbrook will participate.

In the event of unfavorable weather or jet stream conditions, the launch will occur at a later date. Be sure to check www.qsl.net/W5SJZ and other Ham Radio forums and news sources for later information. The public is invited to come out to the Hillsboro Municipal Airport, located at Exit 3 on Interstate Highway 35W, to watch the launch.

NTBP is a group of Amateur Radio operators from Fort Worth and Dallas and has launched balloons from the Cleburne, Clifton and Hillsboro airports since 1991. This is the second launch during the last year and is funded by the Amateur Radio operators associated with the NTBP.

Please send an email to kd5day@ev1.net for further information. 

Amateur Radio Group to Fly High From the Hillsboro, Texas Airport

The eleventh mission of the North Texas Balloon Project (NTBP) is planned for launch about 8:30 AM on March 13, 2004 from the municipal airport in Hillsboro, Texas, just south of Fort Worth and Dallas. Two payload packages containing sensors and amateur radios will be carried to nearly 100,000 feet in about 90 minutes by a weather balloon and return via parachute in about 25 minutes. Mobile recovery teams will use position reports from the onboard GPS and APRS transmitter on 144.390 MHz and radio direction-finding techniques to recover the payloads.

Pre-launch activities will begin about 7:00 AM with the HF Launch Net on 7260 +/- 15kHz LSB beginning around 8:00 AM. A cross-band repeater will be activated soon after launch. Uplink is 445.800 MHz and downlink is 147.560 MHz. Handheld VHF radios and scanners can receive the downlink easily. At the peak altitude, ham radio operators from Texas, Oklahoma, Arkansas, Louisiana and Kansas can contact each other using the cross-band repeater. Video from onboard cameras is transmitted at 1256.000 MHz FM-NTSC for reception by anyone with FM ATV capability.



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